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Argiope lobata (Pallas, 1772) - Italy, Sicily (PA): Monte Pellegrino

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The genus* Argiope *Audouin, 1826 (Araneae Araneidae).

Argiope Audouin, 1826 (Araneae Araneidae) is a genus of spiders belonging to the family Araneidae Clerck 1757. This genus includes 85 species and 3 subspecies, distributed on every continent, excluding the poles. The name of this genus, which derives from Greek, means bright white sight and refers precisely to the conspicuousness of these spiders that show a bright white or yellow background color, broken by black transverse bands. There is a very marked sexual dimorphism in this genus. The females, very large, reach sizes ranging from 14 to 25 mm, while the males range from 4 to 6 mm. Even the circular and regular web makes this genus easily recognizable. In fact, the webs are very large, built between shrubs or stems and with a central zigzag "*stabilimentum*".
On the cover photograph, a specimen of *A. lobata* (Pallas, 1772) is shown while it feeds on *Graphosoma* sp. (Hemiptera), trapped in its web. Same species and station for the photo on the right.

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Butterflies (Lepidoptera Rhopalocera) of the Bor Wildlife Sanctuary, Wardha, Maharashtra, Central India

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ABSTRACT The diversity of butterfly species (Lepidoptera Rhopalocera) was studied in the Bor Wildlife Sanctuary, Wardha district area (Central India) of 138.12 km^2 from 2011 to 2017. A total of 114 species of butterflies belonging to 6 families were recorded. Most of the butterflies recorded belong to the family Nymphalidae (35 species). 34 Lycaenidae species were recorded. A total of 18 Hesperiidae and 18 Pieridae species were recorded, 8 species were recorded from the Papilionidae and 1 species from the Riodinidae family. Among the 114 butterflies recorded, 9 species come under the protection category of the Indian Wild Life (protection) Act 1972 (i.e., *Pachliopta hector*, *Appias albina*, *Appias libythea*, *Eurema andersonii*, *Euploea core*, *Hypolimnas misippus*, *Euchrysops cnejus*, *Lampides boeticus*, *Ionolyce helicon*, *Baoris farri*). The observations support the value of the National Park (Reserve forest) area in providing valuable resources for butterflies.

KEY WORDS Lepidoptera; diversity; Bor wild life Sanctuary; Wardha; Mahrashtra.

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INTRODUCTION

Bor Wildlife Sanctuary was declared as a tiger reserve in July 2014. It is located near Hingani in Wardha District, Maharashtra. It is a home to a variety of wild animals. The reserve covers an area of 138.12 km^2 (53.33 sq. mile) at 20°57' N and 78°37' E altitude, which includes the drainage basin of the Bor Dam. Bor Wildlife Sanctuary is covered with southern mixed dry deciduous forest. Teak, ain, tendu, and bamboo are the main species of flora in this sanctuary. Tigers, panthers, bisons, blue bulls, chitals, sambars, peacocks, barking deers, chinkara, monkeys, wild boars, bears, and wild dogs are the important faunas of the sanctuary. It represents the floral and faunal wealth of Satpuda-Maikal Landscape. Satpuda runs along the Northern Boundary of Maharashtra from West to East and meets the Maikal Hill range which comes from Kanha (Figs. 1–3).

Among insect, butterflies are the most beautiful and colourful creatures on the earth, have a great aesthetic value and are called the flying jewels or winged jewels of nature. Butterflies are generally regarded as one of the best and most taxonomically studied groups of insects and well observed, not only by the lepidopterists and entomologists, but also by laymen. They are a very common and widespread species, but our understanding on their real biology and diversity may prove to be startlingly below common expectations (Willmott et al., 2001; Ackery, 1987; Tiple & Khurad, 2009).

The butterflies are a very important unit of ecosystem due to the inter-relationship with plants diversity (Kunte, 2000). Their caterpillars can be reared at home and the transformation from cater-

pillar to butterfly can easily be observed. Therefore, they make excellent subjects for natural history observations and scientific studies. Butterflies are very much important for the pollination as they tend to-visit different flowers for the nectar feeding, which make them an important unit of environment. Butterflies are very sensitive group to environment and are directly affected by changes in the habitats, atmospheric temperature, and weather conditions. They can be good indicators of environment changes (Tiple et al., 2006).

The Indian sub-region hosts about 1,504 species of butterflies, of which 351 in Peninsular India and 334 in the Western Ghats. In Central India, the butterfly diversity was reported earlier by Forsayeth (1884), Swinhoe (1886), Betham (1890, 1891) and Witt (1909). D'Abreeu (1931) documented a total of 177 species occurring in the erstwhile Central Provinces (now Madhya Pradesh and Vidarbha). In the recent past, several workers have studied butterflies from urban, rural, and protected areas of Vidarbha. 65 species belonging to 52 genera representing 7 families from Pench Tiger Reserve (Maharashtra) (Sharma & Radhakrishnan, 2005), 68 species of butterflies of 50 genera were recorded from Tadoba Andhari Tiger Reserve (Sharma & Radhakrishnan, 2006) and 103 species of butterflies were recorded from Melghat Tiger Reserve (Wadatkar, 2008). Tiple & Khurad (2009) reported 145 species of butterflies, of which 62 species were new records for Nagpur city. Recently, Tiple (2010) documented 111 species of

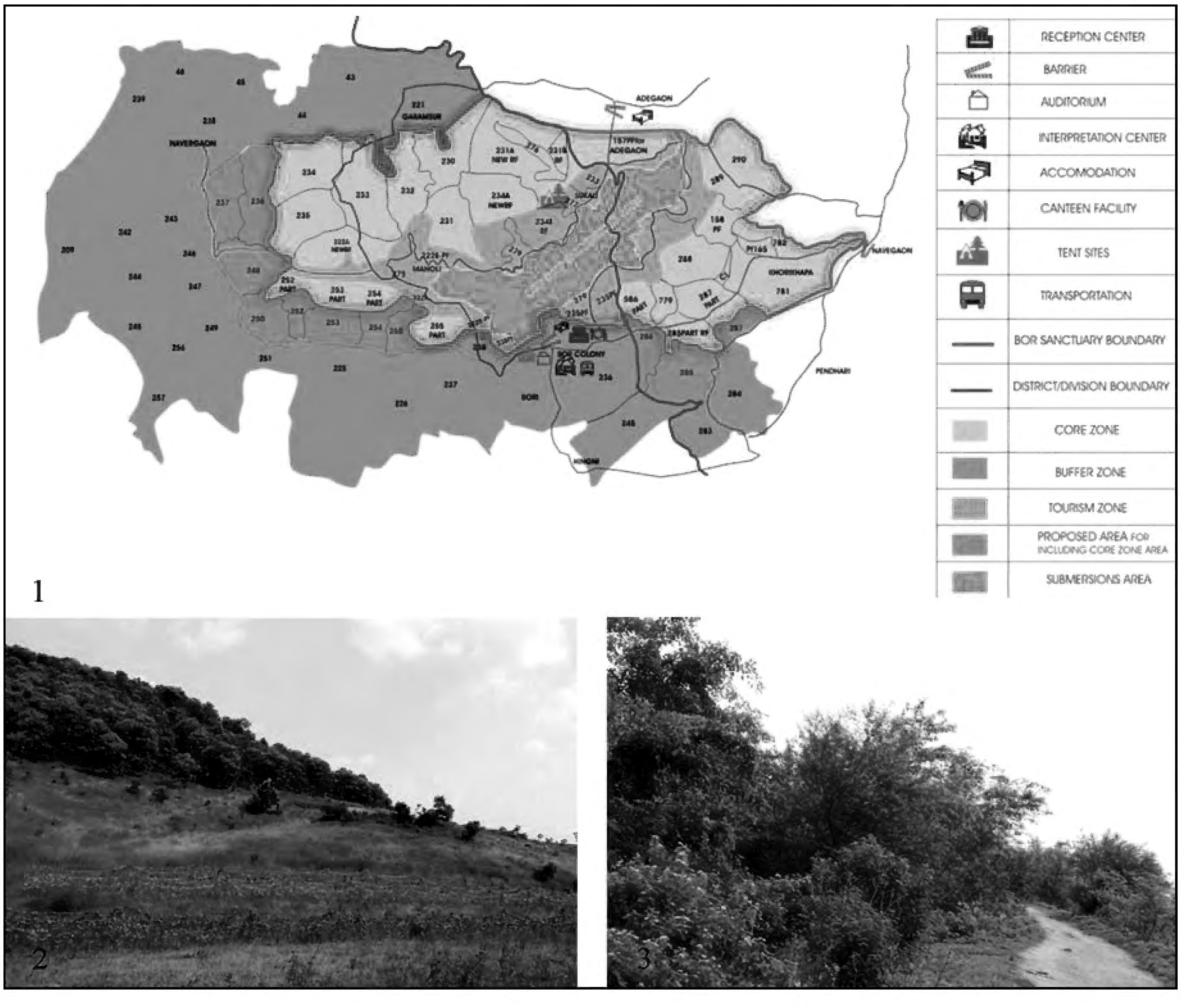


Figure 1. Location map of Bor Wild Life Sanctuary in district Wardha, Maharashtra, Central India (Image Source www.wikimapia.org). Figures 2, 3. Natural environment of Bor Wildlife Santury.

butterflies in Tadoba National Park. The present study was started to examine the diversity of butterflies from Bor Wildlife Sanctuary, Wardha, since there was no known published checklist of butterflies in the Bor Wildlife Sanctuary.

MATERIAL AND METHODS

Butterfly were surveyed in different regions of the Bor wildlife Sanctuary since 2011 to 2017 along the reserve forest areas, buffer zone, lakes, rivers, and surrounding areas. Identification of the butterflies was primarily made directly in the field. In critical condition specimens were collected only with handheld aerial sweep nets and subsequently released without harm. Butterflies were identified from Wynter-Blyth (1957) and Kunte (2000). All scientific names follow Varshney (1983) and common English names are after Wynter-Blyth (1957). Based on the number of sightings, the butterfly species were categorized into very rare (< 2 sightings), rare (2–15 sightings), not rare (15–50 sightings), common (50–100 sightings) and very common (more than 100 sightings).

RESULTS AND DISCUSSION

During the course of study, 114 species of butterflies belonging to 6 families were recorded (Tables 1–3, Figs. 4–15). Most of the butterflies recorded belong to the Nymphalidae (35 species) and Lycaenidae (34 species), followed by Pieridae (18 species), Hesperiidae (18 species), Papilionidae (8 species), and 1 from the Riodinidae (see Table 1). Among the 114 butterflies recorded, 9 species come under the protection category of the Indian Wildlife (protection) Act 1972 (Tiple, 2011; Gupta & Mondal, 2005) (i.e., *Pachliopta hector*, *Appias albina*, *A. libythea*, *Eurema andersonii*, *Euploea core*, *Hypolimnas misippus*, *Euchrysops cnejus*, *Lampides boeticus*, *Ionolyce helicon*, *Baoris farri*).

Seasonal patterns of species richness (flight periods) in Bor Wildlife Sanctuary, are presented in figure 16. Most butterfly species were observed from the monsoon (hot/wet season) to early winter (cool/wet season), but thereafter declined in early summer (March). Among the 114 species of butterflies (*Papilio demoleus*, *Cepora nerissa*, *Eurema brigitta*, *E. hecabe*, *Danaus chrysippus*, *Euploea core*, *Hypolimnas misippus*, *Junonia lemonias*, *Melanitis leda*, *Tirumala limniace*, *Castalius rosimon*, *Catochrysops strabo*, *Luthrodes pandava*, *Zizeeria karsandra*, *Borbo cinnara*) occurred throughout the year (January–December), whereas the remaining 99 species of butterflies were prominently observed only after June-July up to the beginning of summer (April–May). Increasing species abundance from the beginning of the monsoon (June–July) until the early winter (August–November) and decline in species abundance from late winter (January – February) up to the end of summer have also been reported by Tiple et al. (2007), Tiple & Khurad (2009), and Tiple (2010, 2011) in similar climatic conditions in this region of Central India. They further demonstrated that most of the species were noticeably absent in the disturbed and human impacted sites (gardens, plantation, and grassland) and there was no occurrence of unique species in moderately disturbed areas comparable to those of less disturbed wild areas. The present study area, the Bor Wildlife Sanctuary and surrounding areas, is always disturbed and impacted by humans, which may be the reason for overall reduction of the uniqueness of the species from disturbed and impacted sites as compared to the other sites.

In the present study, seasonal occurrence of butterfly species was high from monsoon (hot/wet season) to early winter (cool/wet season), but thereafter declined in early summer (March). The cause of this decline might be non-availability of nectar and larval host plants and scarcity of water (Tiple & Khurad, 2009). Of course, this is but one aspect of the resources used by butterflies in the reserve forest area and a complete picture of habitat structure can only be obtained by researching into all consumable and utility resources (Dennis et al., 2003). Butterfly populations would clearly benefit from planting indigenous, as opposed to exotic, nectar and larval host plants which are the sources of various proteins and salts that are essential for the buildup of a healthy and genetically diverse butterfly population (Tiple et al., 2006). In particular, attention should be paid to the seasonal availability of resources and to resources for less common butterflies on this reserve forest area. All in all, this reserve forest area (Bor Wildlife Sanctuary) provides rich ground not just for conservation, but also for research into butterfly biology for students.

Sr. No.	Scientific Name	Common Name	Status	Occurrence (months)
	Papilionidae(08)			
1	*Graphium agamemnon* (Linnaeus, 1758)	Tailed Jay	C	8-1
2	*Graphium doson* (C. et R. Felder, 1864)	Common Jay	C	8-1
3	*Graphium nomius* (Esper, 1799)	Spot Swordtail	R	3-7
4	*Pachliopta aristolochiae* (Fabricius, 1775)	Common Rose	C	7-2
5	*Pachliopta hector* (Linnaeus, 1758)	Crimson Rose	C	7-2
6	*Papilio demoleus* Linnaeus, 1758	Lime Butterfly	VC	1-12
7	*Papilio polymnestor* Cramer, [1775]	Blue Mormon	R	9-11
8	*Papilio polytes* Linnaeus, 1758	Common Mormon	VC	7-2
	Pieridae (18)			
9	*Belenois aurota* (Fabricius, 1793)	Pioneer	VC	9-2
10	*Appias albina* (Boisduval, 1836)	Common Albatross	VR	11-12
11	*Catopsilia pomona* (Fabricius, 1775)	Common or Lemon Emigrant	VC	1-12
12	*Catopsilia pyranthe* (Linnaeus, 1758)	Mottled Emigrant	VC	7-2
13	*Cepora nerissa* (Fabricius, 1775)	Common Gull	VC	1-12
14	*Colotis fausta* (Olivier, 1804)	Large Salmon Arab	C	8-11
15	*Colotis danae* (Fabricius, 1775)	Crimson Tip	VC	6-10
16	*Colotis etrida* (Boisduval, 1836)	Small Orange Tip	C	8-12
17	*Colotis aurora* Cramer, 1780	Plain Orange Tip	R	8
18	*Ixias pyrene* Linnaeus, 1764	Yellow Orange Tip	R	8-9
19	*Delias eucharis* (Drury, 1773)	Common Jezebel	VC	7-2
20	*Eurema blanda* (Boisduval, 1836)	Three-Spot Grass Yellow	C	7-2
21	*Eurema brigitta* (Stoll, [1780])	Small Grass Yellow	C	1-12
22	*Eurema hecabe* (Linnaeus, 1758)	Common Grass Yellow	VC	1-12
23	*Eurema laeta* (Boisduval, 1836)	Spotless Grass Yellow	VC	7-12
24	*Ixias marianne* (Cramer, [1779])	White Orange Tip	C	8-11
25	*Leptosia nina* (Fabricius, 1793)	Psyche	C	8-1
26	*Pareronia hippie* (Cramer, [1776])	Common Wanderer	C	8-2
	Nymphalidae (35)			
27	*Acraea violae* (Fabricius, 1793)	Tawny Coster	VC	10-12
28	*Ariadne ariadne* (Linnaeus, 1763)	Angled Castor	VC	9-2
29	*Ariadne merione* (Cramer, [1777])	Common Castor	C	10-2
30	*Byblia ilithyia* (Drury, [1773])	Joker	C	6-12
31	*Charaxes solon* (Fabricius, 1793)	Black Rajah	C	10-2
32	*Vanessa cardui* (Linnaeus, 1758)	Painted Lady	C	6-8
33	*Danaus chrysippus* (Linnaeus, 1758)	Plain Tiger	VC	1-12
34	*Danaus genutia* (Cramer, [1779])	Striped Tiger	VC	10-6
35	*Euploea core* (Cramer, [1780])	Common Indian Crow	VC	1-12
36	*Euthalia aconthea* (Cramer, [1777])	Common Baron	C	8-11

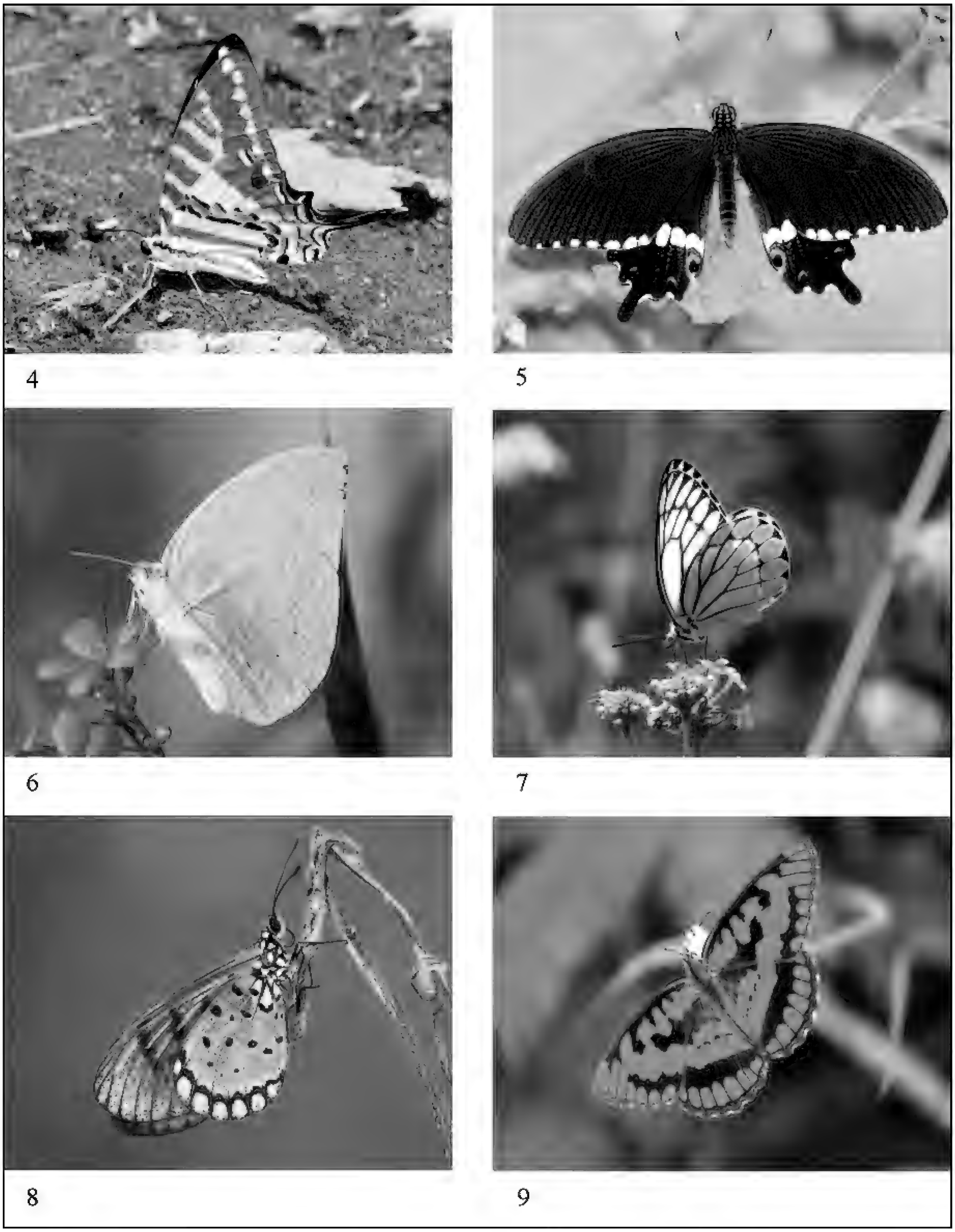
Table 1/1. List of Lepidoptera Rhopalocera recorded from Bor Wild Life Sanctuary, Wardha, Maharashtra, Central India together with common name, status, and Occurrence.

37	*Hypolimnas bolina* (Linnaeus, 1758)	Great Eggfly	C	6-3
38	*Hypolimnas misippus* (Linnaeus, 1764)	Danaid Eggfly	C	1-12
39	*Junonia almana* (Linnaeus, 1758)	Peacock Pansy	VC	6-2
40	*Junonia atlites* (Linnaeus, 1763)	Grey Pansy	VC	7-2
41	*Junonia hierta* (Fabricius, 1798)	Yellow Pansy	C	8-2
42	*Junonia iphita* (Cramer, [1779])	Chocolate Pansy	VC	8-3
43	*Junonia lemonias* (Linnaeus, 1758)	Lemon Pansy	VC	1-12
44	*Junonia orithya* (Linnaeus, 1758)	Blue Pansy	VC	10-4
45	*Lethe europa* (Fabricius, 1775)	Bamboo Treebrown	C	8-3
46	*Melanitis leda* (Linnaeus, 1758)	Common Evening Brown	VC	1-12
47	*Moduza procris* (Cramer, [1777])	Commander	C	8-1
48	*Mycalesis intermedia* (Moore, [1892])	Intermediate Bushbrown	R	8-1
49	*Mycalesis mineus* (Linnaeus, 1758)	Dark Branded Bushbrown	C	8-3
50	*Mycalesis perseus* (Fabricius, 1775)	Common Bushbrown	VC	7-3
51	*Phaedyma columella* (Cramer, [1780])	Short-banded Sailer	C	9-11
52	*Neptis hylas* (Linnaeus, 1758)	Common Sailer	VC	7-3
53	*Neptis jumbah* Moore, [1858]	Chestnut-Streaked Sailer	C	9-11
54	*Phalanta phalantha* (Drury, [1773])	Common Leopard	VC	6-3
55	*Charaxes agrarius* (Swinhoe, 1887)	Anomalous Nawab	C	2-3
56	*Symphaedra nais* (Forster, 1771)	Baronet	C	10-3
57	*Tirumala limniace* (Cramer, [1775])	Blue Tiger	VC	1-12
58	*Ypthima asterope* (Klug, 1832)	Common Threering	VC	7-9
59	*Ypthima baldus* (Fabricius, 1775)	Common Fivering	C	9-10
60	*Ypthima huebneri* (Kirby, 1871)	Common Fourring	C	11-12
61	*Ypthima inica* (Hewitson, 1865)	Lesser Threering	C	9-12
	Riodinidae (1)			
62	*Abisara bifasciata* Moore, 1877	Double-banded Judy	R	8-10
	Lycaenidae (34)			
63	*Acytolepis puspa* (Horsfield, [1828])	Common Hedge Blue	VC	9-2
64	*Amblypodia anita* Hewitson, 1862	Leaf Blue	VC	8-9
65	*Anthene lycaenina* (Felder, 1868)	Pointed Ciliate Blue	C	8-11
66	*Arhopala amantes* (Hewitson, 1862)	Large Oakblue	C	5-6
67	*Arhopala pseudocentaurus* (Doubleday, 1847)	Western Centaur Oakblue	VR	10
68	*Azanus jesous* (Guérin-Méneville, 1849)	African Babul Blue	C	10-2
69	*Azanus ubaldus* (Stoll, [1782])	Bright Babul Blue	R	11-2
70	*Castalius rosimon* (Fabricius, 1775)	Common Pierrot	VC	1-12
71	*Catochrysops strabo* (Fabricius, 1793)	Forget-Me-Not	VC	1-12
72	*Chilades lajus* (Stoll, [1780])	Lime Blue	VC	8-12
73	*Luthrodes pandava* (Horsfield, [1829])	Plains Cupid	VC	1-12
74	*Chilades parrhasius* (Fabricius, 1793)	Small Cupid	C	7-2
75	*Freyeria putli* (Kollar, [1844])	Eastern Grass Jewel	C	7-12

Table 1/2. List of Lepidoptera Rhopalocera recorded from Bor Wild Life Sanctuary, Wardha, Maharashtra, Central India together with common name, status, and Occurrence.

76	*Virachola isocrates* (Fabricius, 1793)	Common Guava Blue	C	8-10
77	*Euchrysops cnejus* (Fabricius, 1798)	Gram Blue	VC	6-3
78	*Everes lacturnus* (Godart, [1824])	Indian Cupid	C	12-2
79	*Jamides bochus* (Stoll, [1782])	Dark Cerulean	C	7-2
80	*Jamides celeno* (Cramer, [1775])	Common Cerulean	VC	7-3
81	*Lampides boeticus* (Linnaeus, 1767)	Pea Blue	VC	8-3
82	*Leptotes plinius* (Fabricius, 1793)	Zebra Blue	VC	7-3
83	*Petrelaea dana* (de Nicéville, [1884])	Dingy Lineblue	C	8-9
84	*Prosotas dubiosa* (Semper, [1879])	Tailless Lineblue	C	7-9
85	*Prosotas nora* (Felder, 1860)	Common Lineblue	C	7-3
86	*Psuedozizeeria maha* (Kollar, [1844])	Pale Grass Blue	C	8-3
87	*Rapala iarbus* (Fabricius, 1787)	Common Red Flash	C	8-12
88	*Spindasis ictis* (Hewitson, 1865)	Common Shot Silverline	C	6-8
89	*Spindasis schistacea* (Moore, [1881])	Plumbeous Silverline	C	7-8
90	*Spindasis vulcanus* (Fabricius, 1775)	Common Silverline	VC	8-2
91	*Tarucus balkanicus nigra* Bethune-Baker, [1918]	Black-spotted Pierrot	C	8-1
92	*Tarucus callinara* Butler, 1886	Spotted Pierrot	C	8-2
93	*Tarucus nara* (Kollar, 1848)	Rounded Pierrot/ Striped Pierrot	VC	7-2
94	*Zizeeria karsandra* (Moore, 1865)	Dark Grass Blue	VC	1-12
95	*Zizina otis* (Fabricius, 1787)	Lesser Grass Blue	VC	6-3
96	*Zizula hylax* (Fabricius, 1775)	Tiny Grass Blue	VC	6-3
	Hesperiidae (18)			
97	*Badamia exclamationis* (Fabricius, 1775)	Brown Awl	VC	8-11
98	*Baoris farri* (Moore, 1878)	Paintbrush Swift	R	10-12
99	*Borbo bevani* (Moore, 1878)	Bevan's Swift	C	8-11
100	*Borbo cinnara* (Wallace, 1866)	Rice Swift	VC	1-12
101	*Caltoris kumara* (Moore, 1878)	Blank Swift	C	10-12
102	*Celaenorrhinus leucocera* (Kollar, [1844])	Common Spotted Flat	R	8-9
103	*Coladenia indrani* (Moore, [1866])	Tricolour Pied Flat	C	9-12
104	*Hasora badra* (Moore, [1858])	Common Awl	C	7-9
105	*Hasora chromus* (Cramer, [1780])	Common Banded Awl	VC	9-10
106	*Hasora taminatus* (Hübner, 1818)	White Banded Awl	C	8-10
107	*Parnara naso*(Fabricius, 1798)	Straight Swift	C	9-12
108	*Pelopidas mathias* (Fabricius, 1798)	Small Branded Swift	VC	7-12
109	*Pseudocoladenia dan* (Fabricius, 1787)	Fulvous Pied Flat	R	9
110	*Spialia galba* (Fabricius, 1793)	Indian Skipper	VC	8-3
111	*Suastus gremius* (Fabricius, 1798)	Indian Palm Bob	C	7-12
112	*Telicota bambusae* (Moore, 1878)	Dark Palm Dart	VC	8-12
113	*Telicota colon* (Fabricius, 1775)	Pale Palm Dart	C	7-10
114	*Udaspes folus* (Cramer, [1775])	Grass Demon	C	9-12

Table 1/3. List of Lepidoptera Rhopalocera recorded from Bor Wild Life Sanctuary, Wardha, Maharashtra, Central India together with common name, status, and Occurrence.



Figures 4–9. Lepidoptera Rhopalocera recorded from the natural environment of Bor Wildlife Santury, Wardha, Maharashtra, Central India. Figure 4: Spot Swordtail, *Graphium nomius* (Esper, 1799). Figure 5: Common Mormon, *Papilio polytes* Linnaeus, 1758. Figure 6: Common Emigrant, *Catopsilia pomona* (Fabricius, 1775). Figure 7: Common Jezebel, *Delias eucharis* (Drury, 1773). Figure 8: Tawny Coster, *Acraea violae* (Fabricius, 1793). Figure 9: Joker, *Byblia ilithyia* (Drury, [1773]).

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Figures 10–15. Lepidoptera Rhopalocera recorded from the natural environment of Bor Wildlife Santury, Wardha, Maharashtra, Central India. Figure 10: Danaid Eggfly, *Hypolimnas misippus* (Linnaeus, 1764). Figure 11: Blue Pansy, *Junonia orithya* (Linnaeus, 1758). Figure 12: Baronet, *Symphaedra nais* (Forster, 1771). Figure 13: Pea Blue, *Lampides boeticus* (Linnaeus, 1767). Figure 14: Tiny Grass Blue, *Zizula hylax* (Fabricius, 1775). Figure 15: Small Branded Swift, *Pelopidas mathias* (Fabricius, 1798).

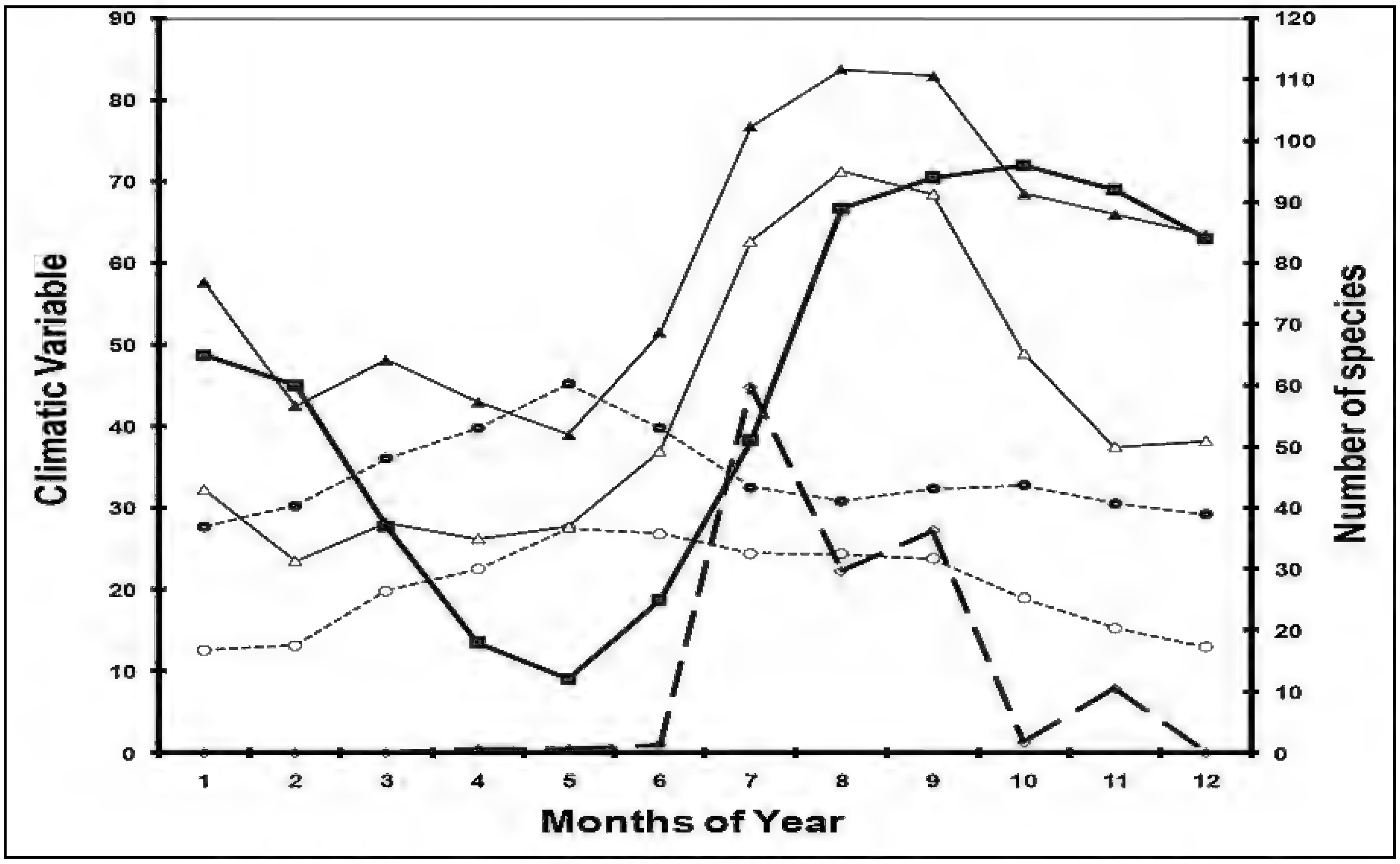

Figure 16. Seasonal distribution in number of species inside and around Bor Wild Life Sanctuary. Right scale: black squares, number of species. Left scale: climate variables, circles, temperatures (0 °C); closed circles, maximum mean temperatures (0 °C); open, minimum mean temperatures (0 °C); triangles, relative humidity (%); closed triangles, maximum relative humidity (%); open triangles, minimum relative humidity (%); diamonds, rainfall (cm).

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Comparative biometrics of Saurel *Trachurus trachurus* (Linnaeus, 1758) (Perciformes Carangidae) in the Algerian coast lines

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ABSTRACT During 2012–2013, a comparative biometric study was conducted on a coastal marine teleost fish of the Carangidae family *Trachurus trachurus* (Linnaeus, 1758). The comparison is made on the basis of seven samples obtained along the Algerian coastline. From East to West: El-kala, Annaba, Skikda, Collo, Jijel, Algiers, and Oran, carrying out 36 morphometric and meristic measurements on each fish. ANOVA Fixed-Variance Analysis of Variance shows the existence of significant differences between the seven sites for 36 variables, as well as the existence of a sexual dimorphism for 22 measured variables and the absence of significant differences for 14 variables out of a total of 36 studied variables. The comparison between the seven sites by MANOVA multivariate statistical tests confirms the results obtained by the ANOVA.

KEY WORDS Algerian littoral; biometric study; *Trachurus trachurus*; univariate statistical test.

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INTRODUCTION

The study of the biometric or morphometric characters of the pelagic fish Saurel *Trachurus trachurus* (Linnaeus, 1758) (Perciformes Carangidae) by using morphometric and meristic measured variables on samples obtained along the Algerian littoral is the object of our research. In addition, it is the subject of numerous studies devoted to the various aspects of the biology of this species, *T. trachurus*, among which we may mention those of Letaconnoux (1951), Macer (1977), Porumb & Porumb (1979), Korichi (1988), Arias & Drake (1990), Benzohra & Millot (1995), Choulika (2002), Mézédjri (2003), Grimes (2010), Slamene et al. (2012).

This study deals with the biometric comparison of seven sites of the Algerian littoral. Thus, the existence of a sexual dimorphism between males and females of the fish.

MATERIAL AND METHODS

Data collection

This study is carried out on fishes caught by using sardine nets and purse seines as fishing gear, trawlers, and small crafts.

The biometric study is based on seven samples obtained on the Algerian coast. From East to West:

El-kala, Annaba, Skikda, Collo, Jijel, Algiers, and Oran (Fig. 1).

A minimum sample of 30 individuals is taken into consideration at each site, respecting as much as possible all present size classes. Each individual is wrapped in a plastic film immediately after collection to avoid damage, and it is put in the freezer at -20 °C. In the laboratory, a series of 36 morphometric and meristic measurements are made on each fish (Table 1; Fig. 2). These measurements were made on the basis of previous studies to obtain as much information as possible on these fishes studied. All metric measurements are made, to the nearest millimeter, using a dry point compass. The meristic measurements are made, under a binocular loupe, by means of a count. Sex determination was performed after fish dissection.

Statistical data analyses

Univariate statistical analyses. To describe well the different characteristics obtained in the sites, we calculated some basic statistical parameters such as the arithmetic mean ($\bar{x}$), the variance (s2), and the standard deviation (s).

To compare the averages for each of the 36 characteristics between the seven sites, we used the one-way, fixed-ranking model of the variance analysis. The gender factor is completely hierarchical to the site factor. This test consists in comparing the averages of several populations at random, simple and independent random samples (Dagnélie, 1970, 2006).

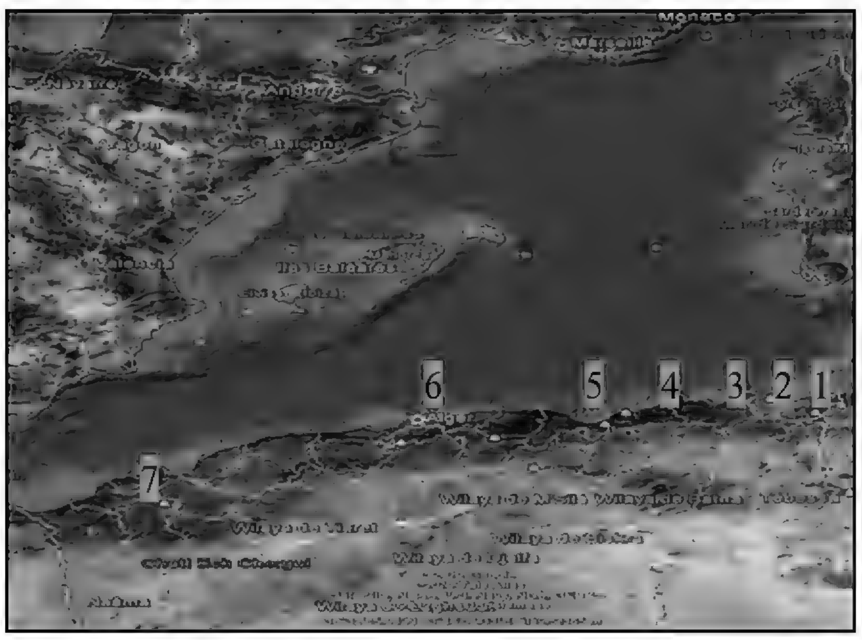

Figure 1. Location of study sites of the Algerian littoral: El Kala Gulf (1), Gulf of Annaba (2), Gulf of Skikda (3), Gulf of Collo (4), Gulf of Jijel (5), Bay of Algiers (6), Gulf of Oran (7).

This ANOVA univariate analysis of variance analysis was used to compare, on one hand, between the 7 sites, and on the other hand, between the sexes in the sites, the averages of the 36 variables.

The calculations are performed by using the Minitab software GLM procedure (Minitab s.s., 2013) for each of the 36 variables at the 7 sites.

Multivariate statistical analyses. The multivariate variance analysis or the dispersion analysis aim to compare the averages of more than two populations for several variables.

This method is an extension of the univariate variance analysis, in which we have several variables that were observed simultaneously on the same individuals.

The comparison of the 7 sites and between sexes in the sites for all 36 studied variables, was performed by using MANOVA multivariate variance analysis using three statistical tests which are: Wilk's lambda, Lawley-Hotteling, and Pillai's trace (Dagnélie, 1970, 1986, 2006).

The three tests cited above and proposed by Palm (2000) and Dagnélie (1970, 2006) are all asymptotically equal in power and no test can be recommended in a systematic way, in preference to others (Dagnélie, 1986). According to Huberty (1994), the Wilk's test is the most popular.

All calculations were performed by a statistical analysis of Minitab Version 16 and statistical processing software (Minitab s.s., 2013).

The bibliography consulted for this work, in addition to the one mentioned, is listed as follows: Letaconnoux (1951); Macer (1977); Porumb & Porumb (1979); Korichi (1988); Arias & Drake (1990); Benzohra & Millot (1995); Choulika (2002); Mézédjri (2003); Grimes (2010); Slamene et al. (2012); FAO (2013); Abla et al. (2018).

RESULTS AND DISCUSSION

Univariate statistical analyses

To better describe the different variables that characterize individuals (fish) studied in seven different sites and for each gender, we calculated some basic statistical parameters such as arith-

metic mean (x), which is a position parameter and central tendency, the standard deviation (s) which measures the dispersion of data around the mean (x), and the number that tell us about the importance of the data processed. The results of the description of the data obtained for the various variables and for a total of 334 studied fishes comparing between the seven sites of the Algerian coastline shows that the number of males is greater than the number of females for the sites of the Gulf of El-kala, Skikda, and Collo, while we note the opposite for the sites of the Gulf of Annaba, Jijel, Algiers, and Oran.

In contrast, the results obtained for the description of data by sex (sites) shows that the averages for the different variables are slightly higher for females than for males, except for the Gulf of Skikda, in which we note the reverse, with the averages of males higher than females. This may suggest a possible sexual dimorphism.

The comparison, firstly of the seven sites between them and, secondly, of both sexes in each site between them, was performed, and for each variable, using the univariate analysis of variance with two criteria fixed classification (sex and site) hierarchical model. The use of the univariate analysis variance ANOVA, and the results are obtained by using the GLM command of the MINITAB software.

The results of the ANOVA applied to each of the 36 variables measured are included in Table 2 to the comparison between the sites and between two sexes in the sites.

We now have to compare between the seven sites the equality of the averages of each measured characteristic.

Examination of Table 2 shows the existence of very highly significant differences between the 7 sites for all 31 morphometric measured variables and the meristic variables with the exception of one variable: Brsu, where the differences are highly significant at the level $\alpha = 1\%$.

Moreover, the examination of Table 2 shows the absence of significant differences for 14 out of 36 variables. The variables that show significant differences at the $\alpha = 5\%$ level are Lt, Lppc, Lcep, Lpdo, Poor, Pror, Lcra, Lapc., Hpv, Hdo, Hpdc, Baan, dopc, pcpv, pvan. Variables where the differences are highly significant are: Lf, Lppv, Dopv, Lpop, Bado. The variables doan and Hpc have very highly significant differences at the level $\alpha = 0.1\%$.

Number	Code	Description
Morphometric measurements		
1	Lt	Total length
2	Lf	At fork length
3	Ls	Standard length
4	Lpan	Length pre-anal
5	Lppv	Length pre-pelvic
6	Lppc	Length pre-pectoral
7	Lcep	Cephalic length
8	Lpdo	Length pre-dorsal
9	Dopv	Dorsal / pelvic distance
10	Doan	Dorsal / anal distance
11	Doca	Dorsal / Caudal Distance
12	Lman	Mandible length
13	Lmax	Maxillary length
14	Poor	Distance post-orbitaire
15	Dor	Diameter Orbital
16	Pror	Length Pre-orbital
17	Lpop	Length pre-operculum
18	Lain	Inorbital Width
19	Lcra	Head width
20	Mist	Length mandible / isthmus
21	Lapc	Distance between pectoral insertions
22	Hpc	Pectoral Height
23	Hpv	Pelvic Height
24	Hdo	Dorsal Height
25	Han	Anal Height
26	Hpdc	Peduncle Height
27	Bado	Dorsal Height
28	Baan	Anal Height
29	Dopc	Distance dorsal/pectoral
30	Pcpv	Distance pectoral/pelvic
31	Pvan	Distance pelvic/anal
Meristic counting		
32	Cæc	Cæc Number of pyloric caecum
33	Brin	Number of lower gill rakers of the 1st left branchial arch
34	Brsu	Number of upper gill rakers of the 1st left branchial arch
35	Rypc	Number of rays of the left chest
36	Rypv	Number of left pelvic rays

Table 1. Morphometric and meristic variables studied.

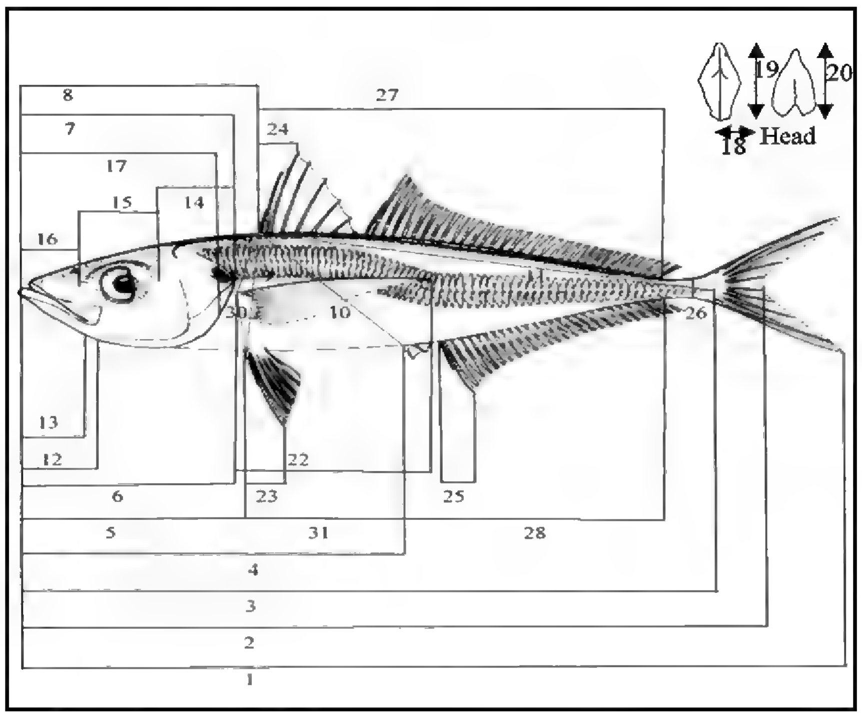

Figure 2. Morphometric measurements taken on each fish.

This leads us to conclude the existence of a sexual dimorphism between males and females for the 22 variables mentioned above.

Multivariate statistical analyses

The MINITAB MANOVA command applied to the data obtained from the seven sites to perform the multivariate analysis with two fixed classification criteria and whose sex factor is hierarchical in the site factor, gives the results represented by Tables 3, 4.

For each of the two tables, the three Wilk's, Lawley-Hotelling, and Pillai's tests yield the same results. That is to say, the examination of Table 3 shows that the 3 tests conclude that there are very highly significant differences between the 7 sites, for all the morphometric and meristic observed characters on the *T. trachurus*.

In addition, the examination of Table 4 shows that the 3 tests lead to the absence of significant differences between the two sexes for each of the 7 sites for all 36 studied variables.

In the first case as in the second case, the MANOVA tests completely confirm the results of the univariate analysis of variance (ANOVA) obtained previously.

The significant differences found between the seven sites depend on several factors. It may be related to the dominant ecological factors in each region or they can also be due to the sampling period. The climate, the hydrodynamics, and water courses in each region are a source of nutrients for phytoplankton, which is the base of the trophic chain. In addition, the temperature differences between the different chosen stations can lead to significant differences and impact on reproduction.

Factors					
		Sites		Sexes (sites)	
n°	Variables	F	P	F	P
1	Lt	71.10	0.000***	2.63	0.012*
2	Lf	72.59	0.000***	2.82	0.007**
3	Ls	53.18	0.000***	0.90	0.504 ns
4	Lpan	55.66	0.000***	2.01	0.054 ns
5	Lppv	52.19	0.000***	2.97	0.005**
6	Lppc	65.96	0.000***	2.41	0.021*
7	Lcep	63.10	0.000***	2.31	0.026*
8	Lpdo	55.00	0.000***	2.67	0.011*
9	dopv	27.04	0.000***	2.93	0.006**
10	doan	40.53	0.000***	3.98	0.000***
11	doca	52.25	0.000***	0.90	0.511 ns
12	Lman	18.17	0.000***	1.38	0.212 ns
13	Lmax	4.20	0.000***	0.99	0.437 ns
14	Poor	44.59	0.000***	2.67	0.011*
15	Dor	29.16	0.000***	0.99	0.436 ns
16	Pror	31.55	0.000***	2.16	0.038*
17	Lpop	48.57	0.000***	2.82	0.008**
18	Lain	19.72	0.000***	1.58	0.142 ns
19	Lcra	42.55	0.000***	2.16	0.038*
20	Mist	33.87	0.000***	1.30	0.250 ns
21	Lapc	40.77	0.000***	2.14	0.040*
22	Hpc	52.32	0.000***	3.77	0.001***
23	Hpv	27.33	0.000***	2.33	0.026*
24	Hdo	33.29	0.000***	2.44	0.019*
25	Han	8.59	0.000***	1.35	0.226 ns
26	Hpdc	37.38	0.000***	2.06	0.048*
27	Bado	60.95	0.000***	2.82	0.008**
28	Baan	42.96	0.000***	2.13	0.041*
29	dopc	38.12	0.000***	2.23	0.032*
30	pcpv	26.96	0.000***	2.13	0.040*
31	pvan	48.74	0.000***	2.11	0.043*
32	cæc	11.94	0.000***	1.75	0.098 ns
33	brin	5.55	0.000***	0.73	0.646 ns
34	brsu	3.02	0.007**	0.73	0.644 ns
35	rypc	17.78	0.000***	0.88	0.520 ns
36	rypv	6.05	0.000***	0.88	0.520 ns

Table 2. Results of the comparison sexes and the sites between them obtained by ANOVA for each of the 36 studied variables. Note: p >5% = not significant differences, *p = 5% significant differences, **p = 1% significant differences, ***p = 0.1% significant differences, F = value of observed F of the ANOVA, P = Probability.

CONCLUSIONS

This work deals with morphometry (biometrics) of the Carangid pelagic fish on the Algerian coastline from East to West, Saurel *T. trachurus*.

The comparative biometric study between seven sites (El-kala, Annaba, Skikda, Collo, Jijel, Algiers, and Oran) shows that the use of the generalized linear model or the ANOVA analysis applied to each of the 36 measured variables, whether for the site factor or the sex factor in site, reveals the significant

Tests	Value observed of the test	Fobs	P
Wilks'	0.00711	7.879	0.000 ***
Lawley-Hotelling	9.10063	9.155	0.000 ***
Pillai's	3.10427	6.664	0.000 ***

Table 3. Multivariate tests used to test the equality of the vectors of average between the sites. ***p = 0.1% significant differences, F = value of the F_{obs}, P = Probability.

Tests	Value observed of the test	Fobs	P
Wilks'	0.31937	1.087	0.181 ns
Lawley-Hotelling	1.28436	1.107	0.134 ns
Pillai's	1.02225	1.068	0.236 ns

Table 4. Multivariate tests used to test the equality of the vectors of average between two sexes in the sites. ns: p >5% : not significant differences, F = value of the F_{obs}, P = Probability.

differences existed between the seven sites for all 36 variables.

However, for the sex factor, we concluded that there were no significant differences for 14 variables out of 36 and the existence of significant differences for all 22 variables.

We can conclude as possible a sexual dimorphism between males and females of these 22 variables mentioned above.

Multivariate statistical tests confirm the previous univariate results and show that there are significant differences between sites, whereas for all seven sites, there are no significant differences between the two sexes.

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Climatic factors as quality determinant of essential oils and phenolics in *Rosmarinus officinalis* L. (Lamiales Lamiaceae) collected from three geographic areas in Algeria

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ABSTRACT

The present work was aimed to evaluate the effect of the climatic factors on quality and quantity of essential oils and phenolic compounds of the aerial parts of *Rosmarinus officinalis* L. (Lamiales Lamiaceae) collected from three different geographic origins in Algeria (humid, semi arid, and arid). Gas-Chromatography/Mass-Spectroscopy analysis of essential oils revealed important disparities, both quantitatively and qualitatively. α-pinene and camphor as major components were found to range from 16.78 to 40.95% and from 11.24 to 36.72%, respectively. The assessment of total phenolics in water and ethyl acetate extracts of the three samples displayed a content ranging from 58.26 to 114.10 mg GAE (gallic acid equivalent)/g of water extracts and from 73.75 to 167.91 mg GAE/g of ethyl acetate extracts. The flavonoids content was found to vary from 14.63 to 28.86 mg QE (quercetin equivalent)/g of water extracts and from 66.2 to 93.1 mg QE/g of ethyl acetate extracts. Moreover, the HPLC analysis of phenolics revealed the presence of many compounds amongst which Hesperidin and Rosmarinic acid have relatively high contents in both extracts and in the three sites.

KEY WORDS Environment factors; essential oils; flavonoids; *Rosmarinus officinalis*; phenolics.

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INTRODUCTION

Plant secondary metabolites are considered as the major source of supply for pharmaceuticals, food additives, perfumes, savors, and other key compounds in chemistry and bio-chemistry widely used in everyday life. The role of secondary metabolites continues to be a contentious subject. Unlike the primary metabolites, which govern all fundamental physiological processes necessary to the growth and development of plants, secondary metabolites are mandatory in the survival of the

plant in its environment. They constitute an essential part of the armamentaria used by plants in the fight to survive and proliferate. Their role may centre on defense of the producer against predators (herbivores), pathogens, or competitors, on assistance to pollination or seed dispersal, or on protection against or adaptation to extrinsic abiotic factors and in overcoming stress conditions, or combinations of these functions (Ramakrishna & Ravishankar; 2011; Rhodes, 1994; Borges et al., 2013). Environmental factors such as soil composition, temperature, latitude, humidity, light intensity, rainfall, evaporation, minerals, and CO_2 have a fundamental impact on the growth of a plant and accumulation of secondary metabolites and, hence, influence directly the quality of the plant for medicinal application and therapeutic value. Plants have the ability to overcome biological, physical, chemical, and ecological stresses by acclimatizing the buildup of secondary metabolites. Therefore, researches on the impact of ecological factors on the accretion of secondary metabolites in medicinal plants become a hot subject of prime concern (Gobbo-Neto & Lopes, 2007; Guo et al., 2013; Hanif et al., 2018).

Algeria is characterized by a mild Mediterranean climate along the coast, a transitional climate in the northern hills and mountains, a little more continental and moderately rainy, and finally the desert climate of the vast area occupied by the Sahara. The landscapes of Algeria, from desert, mountains, valley, and plateaus to basins support thousands of floral species, many of which are endemic to the country. This striking biodiversity led us to carry out this investigation on the effect of climatic conditions on the content of essential oils and phenolics in both water and ethyl acetate extracts of a widely used medicinal plant, *Rosmarinus officinalis* L. (Lamiales Lamiaceae), taken in three distinguished geographic locations (arid, semi arid, and humid).

Rosmarinus officinalis is a popular fragrant and medicinal plant. Many authors consider this species as the most used folk species worldwide because its volatile components and phenolics are continuously reported to possess important biological assets. Depending on what has been stated in literature, its secondary metabolites may vary according to the harvesting time, extraction technique, climate conditions, geographic origins, phenological stages, etc. The plant is traditionally used as an antispasmodic in renal colic and dysmenorrhoea and in relieving respiratory disorders. It has also been used as an analgesic, antirheumatic, carminative, cholagogue, diuretic, expectorant, antiepileptic, and for human fertility. Other uses are as a general tonic in case of excessive physical or intellectual works and in heart diseases. Externally, it is a rubefacient, and a stimulant for the growth of hair and treatment of eczema of the scalp. Moreover, it was reported to relax smooth muscles of trachea and intestine. The most important constituents of rosemary are caffeic acid and its derivatives, such as rosmarinic acid (Tai et al., 2012; Rozman & Jersek, 2009; Singh & Guleria, 2013; Bajalan et al., 2017; AI-Sereiti et al., 1999).

MATERIALS AND METHODS

Soil and climatic data

The geographic areas covered in this study are Oum El Bouaghi (site 1: semi arid), el Taref (site 2: humid), and Ouargla (site 3: arid). The climate data during 2015 were obtained from the available climate database of the National office of Meteorology, Algeria (Tables 1–3).

Plant material

The aerial parts of *R. officinalis* were collected from Oum El Bouaghi (site 1: semi arid), El Taref (site 2: humid), and Ouargla (site 3: arid). The plants were identified by Pr. A. Zellagui, Oum El Bouaghi University, Algeria. Voucher specimens (RO1, RO2, RO3) of the three sites respectively were deposited in the Laboratory of Natural Resources and Management of Sensitive Environments, University of Oum El Bouaghi, Algeria

Essential oil extraction

Hydrodistillation is used in the extraction of essential oil. This is the simplest and usually the cheapest distillation procedure. It works better for powders and tough materials. In this method, the plant material is heated, by placing it in water, which is brought to the boil. The heat causes the

cell structure of the plant to burst and break down, thus releasing the essential oils. The essential oil molecules and steam are carried along a pipe and conducted through a refrigerator, where they return to the liquid form and collected in a holder. The rising liquid is a mixture of oil and water, and because essential oils are not water soluble, they can be easily separated from the water and siphoned off. In our case, 300 g of each plant sample was ground and subjected to hydrodistillation for 3 hours in a Clevenger type apparatus.

Water extract

500 mL of distilled water were added to 100 g of finely ground dry plant material for each sample. After 60 minutes, the aqueous extract was filtered and dried under vacuum, weighed, and prepared for HPLC analysis.

Ethyl acetate extract

100 g of dry plant material of each sample was subjected to overnight extraction using ethyl acetate. After separation, the organic phase was evaporated and the crude extract was weighed and prepared for further analysis.

Gas Chromatography/Mass Spectrometry (GC/MS) Analysis

GC/MS analyses were obtained on Perkin Elmer mass spectrometer with built-in auto sampler using BPX-20 column (30 m × 0.25 mm × 0.25 μm film). For GC/MS detection, an electron ionization system, ionization energy of 70 eV, was used. Helium was the carrier gas, at a flow rate of 1.3 mL/min. The column temperature was operated under the same conditions as described above.

Identification of the individual components was based on (a) comparison of their GC retention indices (RI) with those of authentic compounds or literature data and (b) computer matching with a mass spectral library and commercial libraries (WILLEY and NIST database/ChemStation data system).

Determination of total phenolic contents

The concentration of phenolics in plant extracts was determined using spectrophotometric method (Singleton et al., 1999). The methanol solution of the extract at the concentration of 1 mg/mL was used in the analysis. The reaction mixture was prepared by mixing 0.5 mL of methanol solution of extract, 2.5 mL of 10% Folin-Ciocalteu's reagent dissolved in water and 2.5 mL 7.5% NaHCO3. Blank was concomitantly prepared, containing 0.5 mL methanol. 2.5 mL 10% Folin-Ciocalteu's reagent dissolved in water and 2.5 mL of 7.5% of NaHCO3. The samples were thereafter incubated in a thermostat at 45 °C for 45 min. The absorbance was determined using spectrophotometer at λmax = 765 nm. The samples were prepared in triplicate for each analysis and the mean value of absorbance was obtained. The same procedure was repeated for the standard solution of gallic acid and the calibration line was constructed. Based on the meas-

parameters	Oum El Bouaghi (site 1)	El Taref (site 2)	Ouargla(site 3)
Latitude and Longitude	35°52′31″ N, 7°06′48″ E	36°46′01″ N, 8°18′49″ E	31°56′57″ N, 5°19′30″ E
Altitude (meters above sea level)	925	24	138
Clay %	21.93	35.45	03.27
Silt %	38.42	16.74	0.3
Sand %	39.6	47.8	96.44
Texture	loam	silty clay	silty
EC (electric conductivity)	0.37	0.37	0.30
pH	7.22	7.47	7.86
$CaCO_3$ T %	19.78	0.86	1.29
$CaCO_3$ A %	14.38	0.00	0.00
OM (organic matter)	5.07	1.69	2.53

Table1. Geographical and soil characteristics of different collection sites.

Analysis parameter	Methods
Particle size (%),	pipette method ROBINSON ISO, 11277
pH Rapport ½.5 at 25°c	Soil referential; 1995
EC (dS/m) rapport 1/5 at 25°c	FAO, 1985
$CaCo_3$ T (%)	G.E.P.P.A
OM (%)	Brochure OLIB

Table 2. Analyses Methods.

ured absorbance, the concentration of phenolics was read (mg/mL) from the calibration line; then the content of phenolics in extracts was expressed in terms of gallic acid equivalent (mg of GAE/g of extract).

Determination of total flavonoids

The content of flavonoids in the examined plant extracts was determined using spectroscopic method (Quettier et al., 2000). The sample contained 1 mL of methanol solution of the extract at a concentration of 1 mg/mL and 1 mL of 2% AlCl3 solution dissolved in methanol. The samples were incubated for an hour at room temperature. The absorbance was determined using spectrophotometer at λmax = 430 nm. The samples were prepared in triplicate for each analysis and the mean value of absorbance was obtained. The same procedure was repeated for the standard solution of quercetin and the calibration line was construed. Based on the measured absorbance, the concentration of flavonoids was read (mg/mL) on the calibration line; then, the content of flavonoids in extracts was expressed in terms of quercetin equivalent (mg of QE /g of extract).

HPLC-TOF/MS analysis

Phenolic content of the plant extracts was determined using Agilent Technology of 1260 Infinity. HPLC System was coupled with 6210 Time of Flight (TOF) LC/MS detector and ZORBAX SB-C18 (4.6 x100 mm, 3.5µm) column. Mobile phases A and B were ultra-pure water with 0.1% formic acid and acetonitrile respectively. Flow rate was 0.6 mLmn-1 and column temperature was 35°C. Injection volume was 10 µL. The solvent program was as follow: 0–1 min 10% B; 1-20 min 50% B; 20-23 min 80% B; 23-30 min 10 % B. Ionization mode of HPLC-TOF/MS instrument was negative and operated with a nitrogen gas temperature of 325 °C. Nitrogen gas flow was 10.0 L min-1, nebulizer of 40 psi, capillary voltage of 4000 V, and finally, fragmentor voltage of 175 V. For sample analysis, dried crude extracts (200 ppm) were dissolved in methanol at room temperature. Samples were filtered passing through a PTFE (0.45 µm) filter by an injector to remove particulates.

RESULTS AND DISCUSSION

Essential oils

The GC-MS fingerprints of essential oils of the three samples were established. Table 4 shows the essential oil composition of *R. officinalis* from the three precited sites, RO1, RO2, and RO3, respectively.

16 compounds were identified in sample RO1, 21 in sample RO2, and 21 in sample RO3, making up a total of 25 different compounds in all samples representing more than 99% of the total oils. All the identified components have been reported previously. The constituents: α-pinene, camphene, limonene, eucalyptol, linalool, camphor, isoborneol, and verbenone account more than 82% of weight in the three samples.

The major compounds in RO1 are α-pinene (40.95%), verbenone (11.90), camphor (11.24%), camphene (8.08%), limonene (5.49%), and isborneol (3.96%). RO2, instead, involves a quite different quantitative order of the major components, namely camphor (19.26%), α-pinene (16.78%), isoborneol (12.29%), verbenone (12.19%), eucalyptol (11.88%), limonene (3.52%). Sample RO3, in turn, contains distinguished chemotypes explicitly: camphor (36.72%), α-pinene (17.16%), eucalyptol (13.88%), iso-borneol (7.58%), camphene (4.92%), and Verbenone (3.44%). All major components showed significant discrepancies between samples. There are many reports regarding the variation of rosemary essential oil according to geographic origin. It was reported that camphor (14.3–17.5%), Eucalyptol (11.0–21.6%), and α-pinene (10.2–12.5%) were the major essential oil components in populations growing in Turkey (Gurbuz et al., 2016). Morocco rosemary was found to be rich in Eucalyptol (47.44%), α-pinene (12.51%), and camphor (7.9%), while α-pinene was the major component of rosemary collected in Spain (24.7%) and France (35.80%) (Chalchat et al., 1993). In Algeria, it was reported that the plant contains Eucalyptol (52.4%), camphor (12.6%), and β-pinene (5.7%) (Boutekedjiret et al., 1998). Pino reported the composition of rosemary from Cuba to be: camphor (34.80%), borneol (11.6%), Eucalyptol (11%), and α-pinene (8.17%) (Pino et al., 1998). Balkan Peninsula rosemary was found

Month	Average Mean Temperature °C			Average Humidity, rate %			Relative precipitation in mm			Relative Evaporation in in mm	
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2
Jan	5.9	11.3	11.4	81	85	52	39	124	1	49	27
Feb	5.7	11.8	14.2	80	83	56	52	82	24	41	19
Mar	9.6	13.7	17.4	71	73	47	22	68	4	86	40
Apr	14.3	15.5	24.4	60	74	36	3	53	0.0	114	31
May	19.1	19	28.9	54	70	38	16	39	0.0	189	38
June	22.4	23	32.3	52	68	30	10	16	0.0	250	48
July	26	25.7	34.3	46	63	30	27	3	0.0	259	52
Aug	25.9	26.5	36	51	65	38	68	5	0.0	208	51
Sept	22.2	24.5	30.9	56	67	45	6	37	1	162	41
Oct	17.4	20.2	24.8	58	73	45	46	72	0.0	184	31
Nov	11.2	16	17.7	77	80	56	44	90	0.0	51	19
Dec	7.8	12.4	12.5	69	82	54	43	105	0.0	48	10
average	**15.62**	**18.30**	**23.73**	**62.91**	**73.58**	**43.91**	**31.333**	**57.83**	**2.5**	**136.75**	**33.91**

Table 3. Climatic data of the three selected sites in 2015.

N	Compound	RT	RO1(Site 1)	RO2 (Site 2)	RO3 (Site3)
1	P-xylene	10.775	-	0.69	0.67
2	α-pinene	12.752	**40.95**	**16.78**	**17.16**
3	Camphene	13.271	**8.08**	**2.46**	**4.92**
4	β-pinene	14.179	1.34	0.67	1.09
5	Myrcene	14.346	-	0.76	0.54
6	Delta -3-carene	15.208	-	1.26	
7	P-cymene	15.675	3.24	1.21	0.60
8	Limonene	15.846	**5.49**	**3.52**	**2.80**
9	Eucalyptol	16.025	**1.30**	**11.88**	**13.88**
10	Gamma-terpinene	16.843	1.29	0.66	0.52
11	Terpinolene	17.917	-	1.23	0.77
12	Linalol	18.169	2.87	3.91	1.42
13	Cyclopentadiene	19.319	-	-	0.54
14	Camphor	20.252	**11.24**	**19.26**	**36.72**
15	Iso Borneol	20.873	**3.96**	**12.29**	**7.58**
16	Bicyclo(3,1,1) heptan-3-one	21.175	-	3.16	-
17	Carvomenthenol	21.185	1.42	-	1.38
18	Alpha-terpineol	21.601	1.38	1.68	1.46
19	Bicyclo(3,1,1)hept-2-ene-2-ethanol	21.957	-	0.92	1.34
20	Verbenone	22.406	**11.90**	**12.19**	**3.44**
21	Urea, phenyl	23.505	-	1.14	-
22	Aceticacid	24.845	-	2.96	-
23	Bornylacetate	24.855	2.64		1.42
24	Beta-caryophyllene	29.510	1.81	1.36	1.26
25	Alpha-Humulene	30.575	1.10	-	0.48

Table 4. *Rosmarinus officinalis* essential oils composition (from the three sites).

sites	water extract	ethyl acetate extract
Site 1	81.63±0.16	123.22±0.31
Site 2	114.10±0.15	167.91±0.35
Site 3	58.26±0.31	73.75±0.07

Table 5. Total phenolics in the two extracts of *Rosmarinus officinalis* (mg GAE /g Dry Weight) (see text).

sites	water extract	ethyl acetate extract
Site 1	28.86±0.31	66.2±0.19
Site 2	28.78±0.02	93.1±0.07
Site 3	14.63±0.08	83.32±0.07

Table 6. Total flavonoids in the two extracts of the two species (mg EQ/g Dry Weight) (see text).

extract compound	W1	W2	W3	EA1	EA2	EA3
Gentisic Acid	4 .953	2.025	20.233			
Chlorogenic Acid	135.152	31.174	97.451	6.339	3.084	0.323
4-Hydroxy Benzoic Acid	119.621	39.320	583.822			
Protocatechuic Acid	14.246	16.941	12.645	1.011	1.402	0.510
Caffeic Acid	11.867	160.719	87.937			
Vanilic Acid		14.015	26.788	0.934	1.529	0.515
Rutin	7.889	2.471	24.260			
P-Coumaric Acid			5.557		1.461	0.134
Chcoric Acid			11.582	1.225	1.173	
Ferulik Acid	7.021	0.370	10.667		3.509	0.498
Hesperidin	**8963.114**	**5412.587**	**14679.306**	**611.031**	**348.168**	**60.900**
Apigenin-7-Glucoside						
Rosmarinic Acid	**1587.827**	**1664.396**	**1653.592**	**1927.5692**	**1314.146**	**41.347**
Salisilic Acid			52.754			
Cinnamic Acid	60.850			4.700		

Table 7. Phenolic compositions of *Rosmarinus officinalis* for the 3 sites. W: water extract, EA: EtOAc extract. Values are given as mg of phenolic compound per kg of dry weight of plant material.

to contain eucalyptol and camphor as the major compounds (Lakušić et al., 2012). Essential oils from 21 localities from Iran were found to contain variable percentages of major components such as: α-Pinene (14.19–21.43%), camphene (3.25–7.58%), 1.8-cineole (5.32–28.29%), camphor (1.58–25.32%), borneol (0.16–9.42%), piperitone (4.21–7.71%), and bornyl acetate (4.14–6.95%) (Bajalan et al., 2017). The Tunisian rosemary from 4 geographic origins was reported to be rich in 1.8-cineol (33.08–37.75%), camphor (13.55–18.13%), α-pinene (8.58–9.32%), α-terpineol (6.79– 8.17%), camphene (5.07–5.58%), borneol (4.08–5.48%), limonene (3.19–3.04%), and p-cymene (2.42–3.11%) (Hcini et al., 2013).

Total phenolics

The content of the total phenolics is determined from a calibration curve of gallic acid taken as standard with a correlation coefficient ($y = 0.0113X + 0.0686$, $R2 = 0.9984$).

The contents of total polyphenols are reported in micrograms of gallic acid equivalent per milligram of dry weight extract (mg GAE/g DW) in Table 5.

The results revealed important fluctuations in total phenolics. Site 2 (humid region) exhibits significant phenolic contents (114.10 and 167.91 mg GAE/g DW). This is certainly due to environmental factors, especially water and nutrients favorable

for the biosynthesis of such elements. Site 3, in turn displays less contents especially in water extracts (58.26 mg GAE/g DW).

Flavonoids content

The flavonoid content, expressed in microgram of quercetin equivalent per milligram of dry weight extract (mg QE/g DW), was determined from the regression curve whose equation is: y = 0.0299 X + 0.0979, R2 = 0.9746.

The flavonoids contents seem to be less location-dependent for the case of water extracts in sites 1 and 2. However, in site 3 the plant displays only half of the other sites content (14.63 mg QE/g DW). Nonetheless, for ethyl acetate extracts, quite important oscillations were observed (66.2–93.1 mg QE/g DW) in site 3 (Table 6).

High performance liquid chromatography analysis

Recognition and quantification of phenolic compounds were carried out using analytical HPLC-TOF-MS and the results are shown in Table 7 expressed as mg of phenol per kg of dry weight of plant material.

Previous reports stated clearly the drastic dependence of these chemical contents with their geographic origins. For example, but not exclusively, the ethanol dry extract from Romanian *Rosmarinus officinalis* contains 3.22% of flavonoids (expressed as rutin equivalent), 34.30% phenol carboxylic acids (expressed as chlorogenic acid equivalent), 31.86% total phenols (expressed as tannic acid equivalent), and 3.29% rosmarinic acid (Gîrd et al., 2017). In Iran, the total phenolics were found to be 4.99±0.054 g of gallic acid equivalent /100g dry leaves instead of 4.99±0.054 g as gallic acid equivalent /100g dry leaves as reported by Tavassoli & Emam Djomeh (2011).

CONCLUSIONS

The increased demand of natural products as substituent of synthetic drugs has rehabilitated concern in large-scale production. Environmental factors have impact on availability of active principles and affect remarkably the secondary metabolites contents in higher plants in medicinal plants, hence, therapeutic value also get influenced. It is well apparent that climate change, soil nature, aridity, and other factors considerably influence water availability, salinity, and several unfavorable circumstances having direct attitude on secondary metabolites yields and qualities. The present work, in the same context, highlights the effect of some abiotic aspects on essential oil and polyphenolic contents of *Rosmarinus officinalis*. Nevertheless, further studies are required to deepen the knowledge towards the establishment of a relationship leading to the use of such stresses as tools to increase the health-related properties of medicinal plant.

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Taxonomic and biogeographical observations on a new population of *Calomera* Motschulsky, 1862 (Coleoptera Carabidae Cicindelinae) from Crete Island (Greece)

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ABSTRACT During a wildlife expedition to Crete Island (Greece), we found a population of *Calomera* Motschulsky, 1862 (Coleoptera Carabidae Cicindelinae), which was new to this island and that we describe as a new subspecies (*C. panormitana cretensis* n. ssp.). In this paper, some taxonomic and biogeographical observations on the *C. aphrodisia* (Baudi di Selve, 1864) group are provided, the validity of the taxon *C. panormitana* is confirmed, and, for nomenclatural stability, a neotypus of *C. lugens* Dejean, 1831, and a lectotypus of *C. panormitana* are designated.

KEY WORDS *Calomera aphrodisia*; *panormitana*; speciation; Mediterranean.

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INTRODUCTION

Calomera aphrodisia (Baudi di Selve, 1864) (Coleoptera Carabidae Cicindelinae) was described as a "variety" of *C. littoralis* (Fabricius, 1787) on the basis of specimens collected by Eugenio Truqui in "*insula Cypro et Asia Minor*" (Baudi di Selve, 1864).

Ragusa (1882) discovered in Sicily, in the same day and in the same locality, "*Cicindela littoralis* var. *lugens* Dahl." and "*Cicindela littoralis* var. *aphrodisia* Truqui". Subsequently, Ragusa (1884, 1904) better distinguished the two mentioned taxa by describing the Sicilian populations of *C. aphrodisia* as a distinct variety that he named "*panormitana*" (Ragusa, 1906).

Piochard de la Brulerie (1885) and Horn & Roeschke (1891), among the two original localities mentioned by Baudi di Selve (1864) for *C. aphrodisia*, reported Cyprus as the locus typicus of this species. Horn (1931) observed that the populations coming from these two localities are different from each other and that the description of Baudi di Selve (1864) corresponded to those coming from the Syrian coasts. Mandl (1981) confirmed these observations and described the populations of Cyprus and Rhodes as a distinct subspecies (*cypricola*).

Cassola (1983, sub *Lophyridia aphrodisia panormitana*) made a detailed review of the literature on the presence and biology of *C. panormitana* in Sicily.

Wiesner (1992) considered *C. panormitana* as a synonym of *C. lugens* Dejean, 1831 and proposed the following classification: *Calomera lugens lugens* (Sicily), *C. lugens cypricola* (Cyprus and Rhodes), and *C. aphrodisia* (Turkish and Syrian coasts). Korell (1994) followed this approach. Cassola (1999) repeated what was previously stated on the Sicilian populations (Cassola, 1983), i.e., that "*lugens* Dejean, 1831" should refer to a chromatic variety of a species of the *C. littoralis* and not of the *C. aphrodisia* and he confirms the validity of *C. panormitana*.

At the moment, some Authors, such as Franzen (2001) and Aydın (2011), follow Cassola (1983, 1999), while others follow Wiesner (1992).

During a wildlife expedition to Crete, we found a population of *Calomera* Motschulsky, 1862, which was new to this island and which showed some peculiar morphological characteristics. We describe below this taxon as a new subspecies, adding also some taxonomic and biogeographical observations on the whole *C. aphrodisi*a group (Figs. 1–8).

MATERIAL AND METHODS

All specimens were collected on sight in their natural environment during daylight hours. In these localities, they have been photographed with a camera Canon Eos 100D - macro 100 mm (I. Sparacio). Collected samples were then prepared in laboratory and male genitalia were extracted. Laboratory photos have been taken using a Canon Eos 450D digital camera equipped with Canon MPE-65 lens and mounted on a Manfrotto micro-slider movement system. The images were then processed with Zerene Stacker 1.0.32 software by M. Romano. All the specimens were studied using an Optika light microscope and a Carl Zeiss light microscope. The taxonomic order and nomenclatural arrangement follow the cited papers.

ACRONYMS AND ABBREVIATIONS. M. Romano collection, Capaci, Palermo, Italy (CMR);

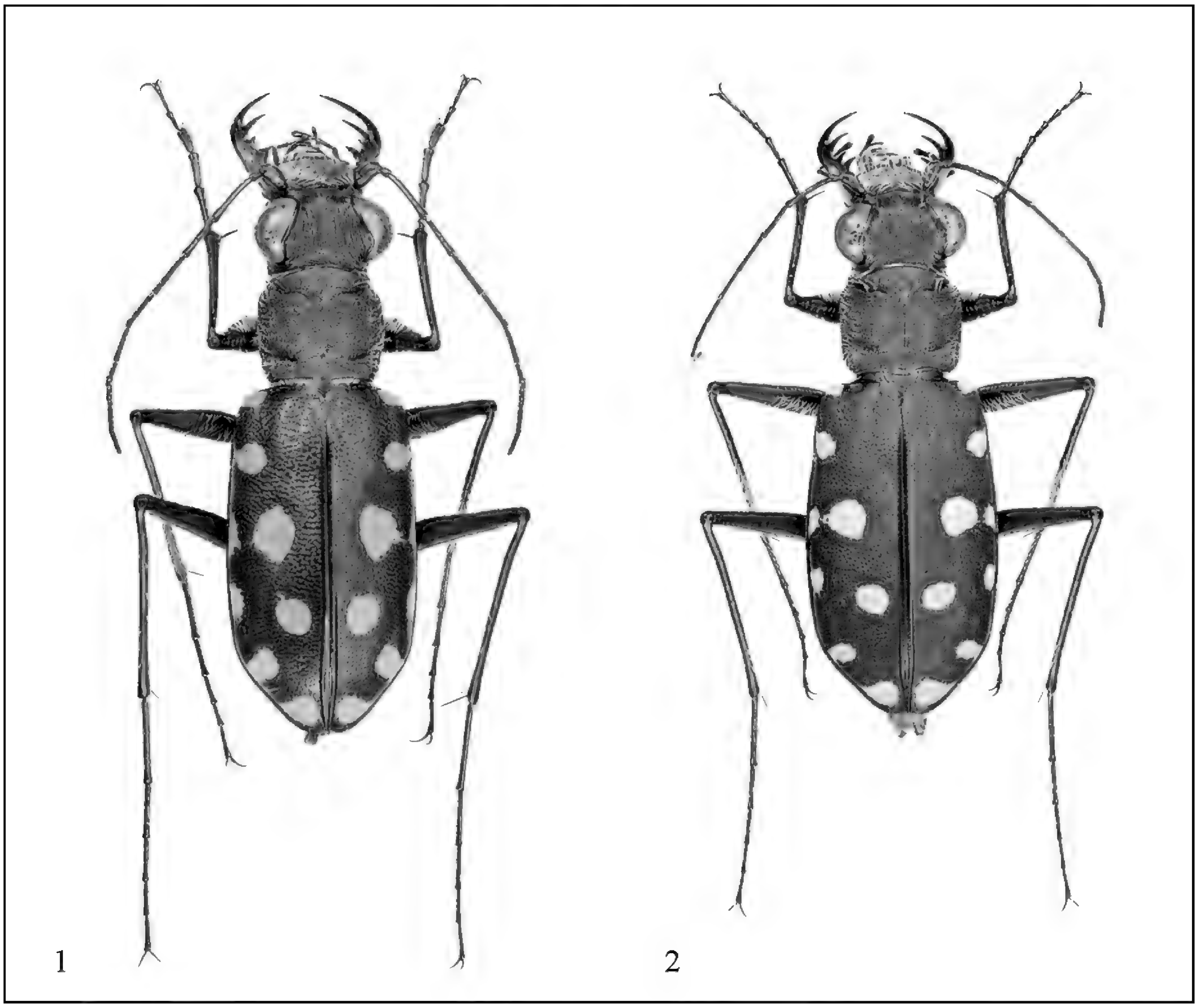


Figure 1. *Calomera aphrodisia* from Lebanon, Beyrouth.
Figure 2. *Calomera panormitana cypricola* from Cyprus, Alsancak Girne.

I. Sparacio collection, Palermo, Italy (CIS); Collection of Dipartimento di Biologia Animale University of Catania, Italy (CMC); Collection of Museo Civico di Storia Naturale "Giacomo Doria", Genova, Italy (MCSNG); Collection of Museum National d'Histoire Naturelle, Paris, France (MNHN); ex/x = specimen/s. Unless otherwise stated, the collector of the beetles in the field is also the owner of the collection where the specimens are preseved.

RESULTS

Systematics

Ordo COLEOPTERA Linnaeus, 1758
Familia CARABIDAE Latreille, 1802
Subfamilia CICINDELINAE Latreille, 1802
Genus *Calomera* Motschulsky, 1862
Species *panormitana* (Ragusa, 1906)

Calomera panormitana cretensis n. ssp.

TYPE MATERIAL. Holotype male, Creta, Chania, Daratsos, 31.V.2014, 35.51509N, 23.98947E (CIS). Paratypes: 5 exx, same locality of the holotype, 2.VI.2014, 35.51621, 23.98173E (CIS), 2 exx, idem (CMR), 1 ex, idem, legit I. Sparacio (MCSNG).

OTHER EXAMINED MATERIAL. *Calomera panormitana panormitana*. E. Ragusa collection (CMC): "*Cicind. aulica* a. *panormitana* Rag.": 1 ex labelled

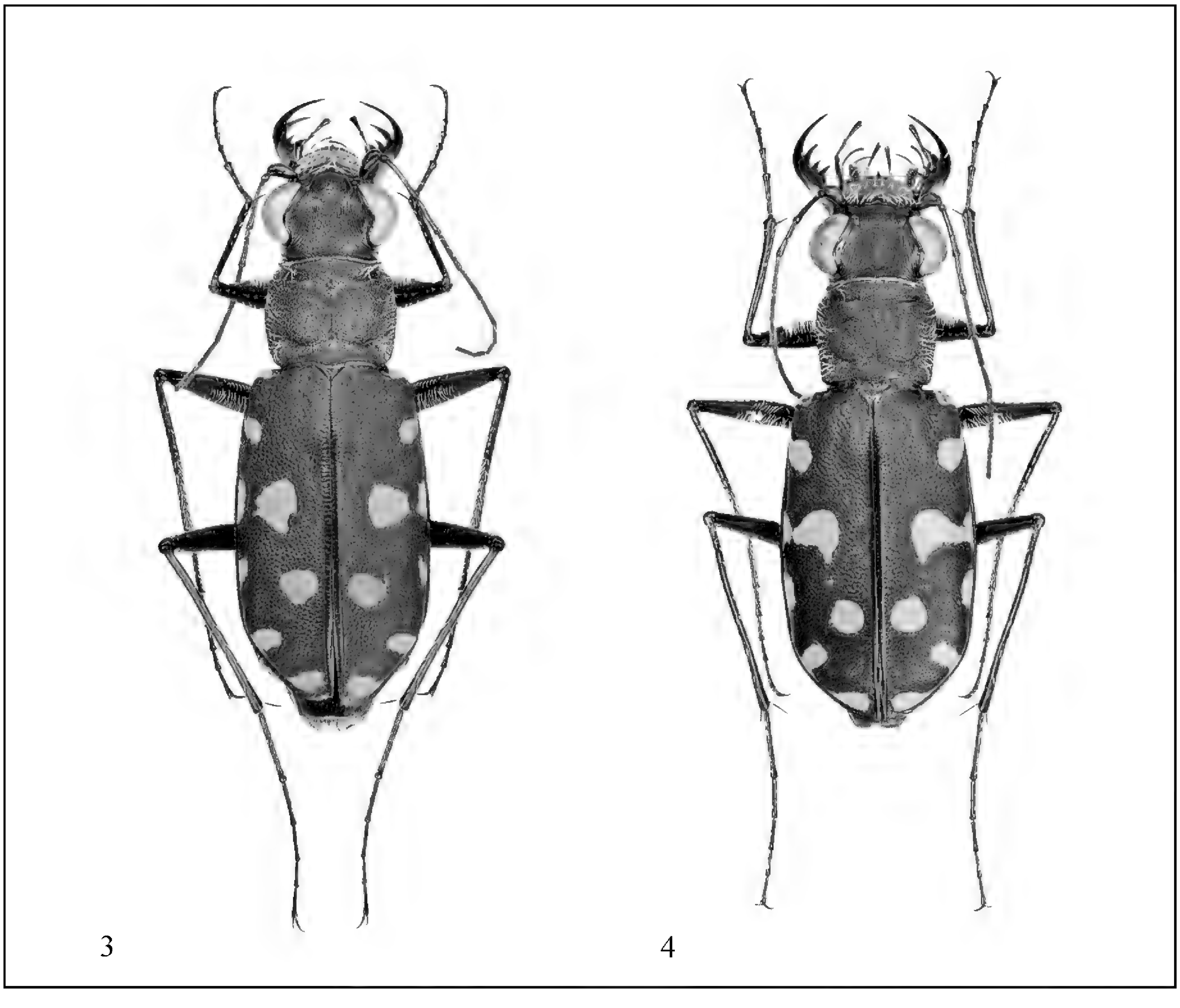


Figure 3. *Calomera panormitana cretensis* n. ssp., Crete (Greece), Chania, Daratsos.
Figure 4. *Calomera panormitana panormitana* from Italy, Sicily, San Vito Lo Capo.

"Sicilia, Mondello, E. Ragusa, 8" - red label: *Calomera panormitana* Ragusa, 1906 - Lectotypus, M. Romano & I. Sparacio des. 2018; 3 exx labelled "Sicilia, Balestr.[ate], E. Ragusa, 6". 8 exx without labels; "*Cicind. aulica* a. *lugens* Rag.": 1 ex labelled "Sicilia, Mondello, 21.7.07; 1 ex labelled "Sicilia, Mondello, E. Ragusa, 8; 7 exx without labels; "*Cicind. aulica* a. *luctuosa* Rag.": 1 ex labelled "Sicilia, 2.8.921, Isola scogliera, A. Modica"; 6 exx without labels. All these specimens, except the Lectotype, have a red label: *Calomera panormitana* Ragusa, 1906 - Paralectotypus - M. Romano & I. Sparacio des. 2018.

San Vito Lo Capo (Trapani), 22.VII.1982, 10 exx (CMR); 23.VIII.1994, 1 ex (CMR); 23.VII.1995, 1 ex (CMR); 2.VIII.1996, 4 exx (CMR); 20.VI.1997, 18 exx (CMR).

San Vito Lo Capo (Trapani), 13.VI.1982, 3 exx (CIS); 28.VI.1997, 4 exx (CIS); Cinisi (Palermo), 6.VIII.1983, 2 exx (CIS); idem, 18.VIII.1983, 5 exx (CIS); idem, 7.VII.1986, 4 exx (CIS); idem, 19.VIII.1989, 2 exx (CIS); idem, 2.VIII.1993, 2 exx (CIS); Carini (Palermo), Torre Pozzillo, 6.VII.1985, 2 exx (CIS); Sferracavallo (Palermo), Punta Matese, 2.VIII.1986, 4 exx (CIS); idem, 6.VIII.1986, 1 ex (CIS); idem, 25.VIII.1988, 3 exx (CIS); idem, 8.VIII.1997, 1 ex (CIS); idem, 10.VII.2000, 1 ex (CIS); idem, 13.VIII.2001, 2 exx (CIS); Isola delle Femmine (Palermo), Punta della Catena, 2.VIII.1993, 2 exx (CIS); idem, 14.VIII.1993, 3 exx (CIS); Castelluzzo (Trapani): Golfo di Cofano, 5/8.VIII.2008, 8 exx (CIS); Sferracavallo (Palermo): Barcarello, 13.VIII.2011, 2 exx (CIS).

<u>*Calomera panormitana cypricola*</u>. Cipro. Cipro coll. Truqui D. Baudi 1872 - Syntypus *Cicindela littoralis* var. *aphrodisia* Baudi, 1864 (red label) - cfr. scheda 7911 - *Cicindela aphrodisia* det R. Gestro - Museo Civico di Genova, 3 exx (MCSNG); Cipro, sud di Larabay, VIII.2005 – *Lophyr. aphrodisia cypricola*, 1 ex (MCSNG); Alsancak Girne Cyprus, VIII.1979 P. Cabella legit - *Lophyridia aphrodisia* Baudi - *Lophyridia aphrodisia* Baudi - Museo Genova coll. P. Cabella (dono 2011) 1 ex (MCSNG); Alsancak Girne Cipro VIII.1979 P. Cabella legit - *Lophyridia aphrodisia* Baudi - *Lophyridia aphrodisia Baudi* - Museo Genova coll. P. Cabella (dono 2011) 4 exx (MCSNG).

<u>*Calomera aphrodisia*.</u> Libano. Beyrouth Acq. E. Deyrolle 1870 - *Cicindela aphrodisia* Baudi det. R. Gestro - Museo Civico di Genova, 1 ex; Beyrouth Acq. E. Deyrolle 1870 / *Cicindela* sp. - *Cicindela aphrodisia* Baudi det R. Gestro - Museo Civico di Genova, 1 ex (MCSNG);

<u>*Calomera littoralis nemoralis* (Olivier, 1790).</u> Italy, Sicily, Balestrate (Palermo), Foci Torrente Calatubo, 13.V.1979, legit I. Sparacio, red label: *Calomera littoralis nemoralis* ab. *lugens* Dejean, 1831- Neotypus - M. Romano & I. Sparacio des. 2018 (MNHN). Ragusa collection (CMC): "*Cicindela* ab. *lugens* Dej.": 1 ex labelled "Sicilia, Oreto, E. Ragusa, 4"; 1 ex labelled "Sicilia, Trapani, E. Ragusa, 8; 1 ex labelled "*Cic.* ab. *Lugens* Dej."; 1 ex labelled "Sicilia, Balestr.[ate], 19/6; 2 exx senza cartellino.

DESCRIPTION OF THE HOLOTYPE. Male. Lenght 14 mm (without labrum). Reddish-bronze green in colour on head, pronotum, front of the elytra, legs and ventral surface; elytra opaque, blackish in the 2/3 posterior of the elytral length, with six white-yellowish spots, well separated, of which four spots at or close to the elytral margin (one humeral, two marginal, and one apical), and two at the discal level. White pubescence is present on the head, sides of the pronotum, legs, and under side.

Head large, with 2 iuxta-orbital setigerous punctures near both eyes and 1 central: each puncture bearing a very fine, long, erect, sensorial seta. Eyes large and prominent. Frons and vertex covered with longitudinal striae, which are deeply developed near orbital edges and somewhat irregular and wrinkly in the middle; clypeus hollow in the middle; labrum testaceous, transverse, nearly three times wider than long, distinctly tridentate forwards (longer median tooth), and 15 long hairs. Mandibles long and pointed, testaceous on the sides of the base. Labial and maxillary palpi black, yellow at the apex; last segment with wider and rounded apex; penultimate segment of maxyllary palpi a little shorter. Antennae long, reaching approximately the middle of the elytral length; scape and 2–4 antennomeres glabrous, metallic, with only 2–3 short hairs; antennomeres 5-11 finely and evenly pubescent with some longer sparse hairs.

Pronotum wider than long (with of pronotum/length of pronotum: 1.18), subparallel sided, slightly wider forward, with dense white decumbent hairs covering the sides; central disk glabrous; front edge slightly protruding forward; anterior and posterior grooves deep; surface wrin-

kled with numerous, dense, and irregular longitudinal striae converging on the median longitudinal groove.

Scutellum triangular with micro-wrinkled surface. Elytra elongated, partially subparallel sided, slightly wider towards the middle, gradually rounded to apical angle, micro-denticulate in their back curve; sculpture formed by small granules well spaced from each other on a finely and regularly microrugous surface.

Abdominal sternites with some punctures on the front and back edges. Legs long, anterior and middle femora with dense, short, and white pubescence; posterior tarsi slightly longer than the corresponding tibiae.

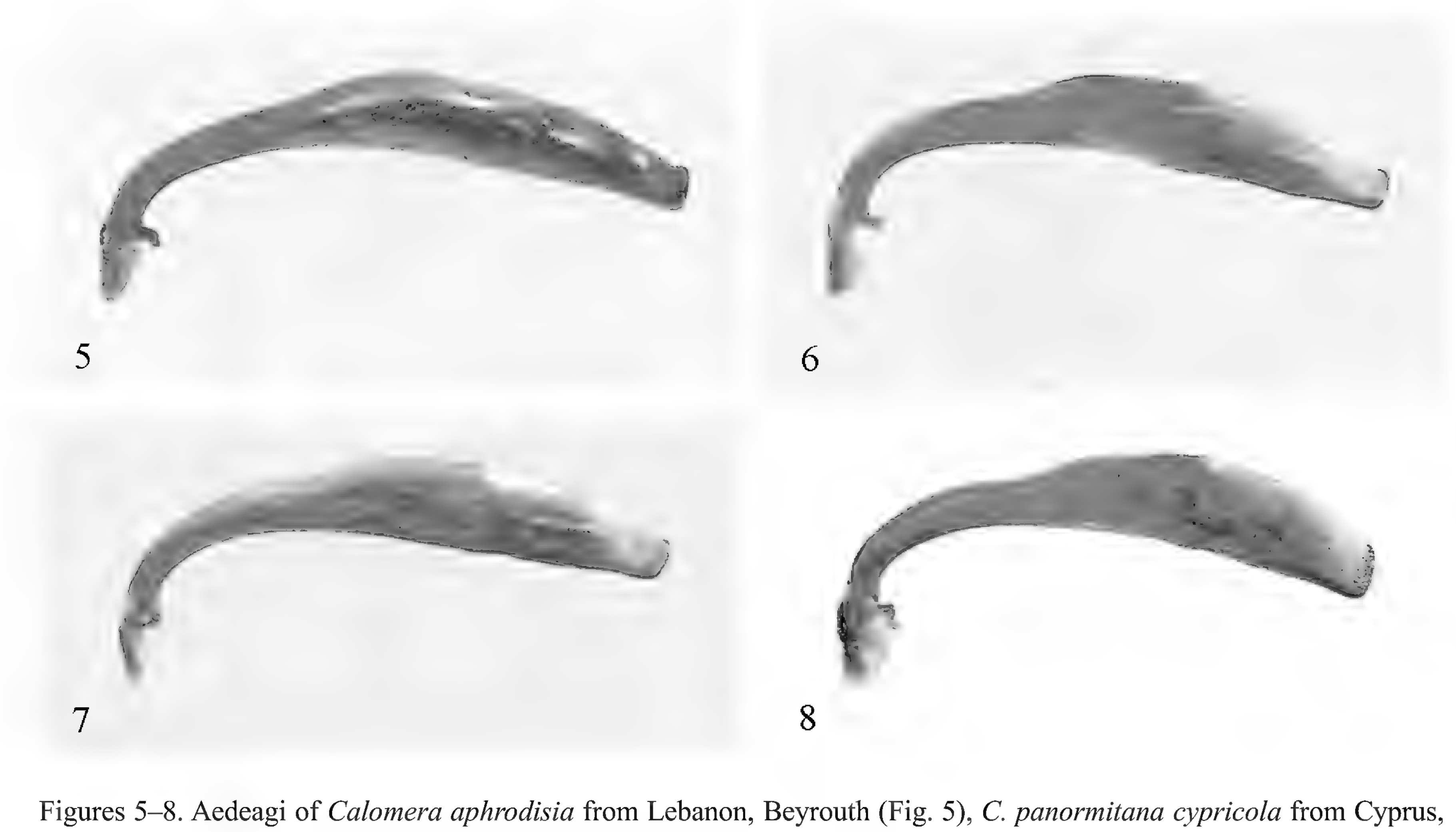
Shape of median lobes of the aedeagus (Fig. 7) wider and shorter forward, longer and arched in the posterior part, apex rounded with the tip slightly curved upwards and with little punctures, latero-apical crest long and detected.

VARIABILITY. The paratypes do not show appreciable morphological differences compared to the holotype. The body length is 13–16 mm; the greenish reflections in some specimens are less evident; labrum with 14–20 long hairs; the females have greater body length and wider elytra.

ETYMOLOGY. The subspecific epithet refers to the type locality, Crete, the largest of the Greek islands.

BIOLOGY AND DISTRIBUTION. *Calomera panormitana cretensis* n. ssp. is found in rocky habitats in the littoral zone, as all the taxa of the aphrodisia group (Ragusa, 1906; Horn 1931, Cassola, 1983, 1999; Sparacio, 1994; Franzen 2001; Lisa, 2002; Austin et al., 2008; Aydin, 2011). *Calomera* species feed on *Ligia* spp. (Isopoda) and other small invertebrates such as *Littorina* spp. and *Gibbula* spp. (Mollusca). Adults are active during late Spring and Summer months (May to August). Larval development occurs in the same habitat of adults (see Cassola, 1983).

Calomera panormitana cretensis n. ssp. is, at present, only known from the type locality (Figs. 9, 10), but it is likely that this subspecies occurs also elsewhere in Crete, in suitable habitat, which have not yet been explored. *Calomera panormitana panormitana* is endemic to Sicily. *Calomera panormitana cypricola* lives in Cyprus, Rhodes, and SW-Turkey. *Calomera aphrodisia* is reported from few localities in southern Turkey, Syria, Lebanon, and Israel (Tschitscherine, 1903; Horn, 1931; Korell, 1994; Franzen, 2001; Avgin & Wiesner, 2009; Jaskuła & Rewicz, 2014; Assmann, 2018).



Figures 5–8. Aedeagi of *Calomera aphrodisia* from Lebanon, Beyrouth (Fig. 5), *C. panormitana cypricola* from Cyprus, Alsancak Girne (Fig. 6), *C. panormitana cretensis* n. ssp., Crete, Chania, Daratsos (Fig. 7), *C. panormitana panormitana* from Italy, Sicily, San Vito Lo Capo (Fig. 8).

CONSERVATION. Tiger beetles are good indicators for habitat changes (Pearson & Cassola, 1992; Rodrigues et al., 1998; Cassola & Pearson, 2000, Pearson & Vogler, 2001; Aydın, 2006, 2011; Choate, 2010).

The species of the *C. aphrodisia* group, in particular, are relics species in the Eastern Mediterranean with very small or restricted populations and in constant reduction. They are herein classified as Vulnerable taxa (VU, according to the IUCN Red List of Threatened Species Categories, 2017), with a high risk of extinction (see Aydın, 2011 and cited references). The decline of these species is due to habitat degradation by human activity and to disturbance due to Summer tourism.

Calomera panormitana cretensis n. ssp. is classified, at the moment, as Vulnerable (VU).

COMPARATIVE NOTES. Morphologically we can distinguish two groups as follows:

1. Narrower, elongate, bright, forebody and elytra darker. Elytra subparallel sides, narrower in the apical third with sculpture formed by big granules, often converging on the sides, on a large microwrinkeld surface. Posterior tarsus much longer than the corresponding tibias (1.32–1.35). Shape of median lobes of the aedeagus slender, little widened at the middle, short and slightly arched in the posterior part, apex rounded with the tip protruding and slightly curved upwards, latero-apical crest long and detected ....*Calomera aphrodisia*

-. Larger, especially in the posterior part of the elytra and in the females, opaque, reddish-bronze or greenish-bronze in colour on head, pronotum, front of the elytra, blackish in the 2/3 posterior of the elytra; elytra with arched sides, dilated and rounded in the apical third with sculpture formed by little and spaced granules on a finely microwrinkled surface. Posterior tarsus a little longer than the corresponding tibias (1.04–1.16). Shape of median lobes of the aedeagus enlarged after the middle, longer and arched in the posterior part, latero-apical crest shorter and less detected............2

2. Body on average larger, lenght 13–16 mm; coloration dorsal surface less dark; discal spot of the elytra small, not extensive, usually well separated from the marginal spot or just united. Pronotum transverse, wider than long. Granules of the elytra smaller and more spaced. Shape of median lobes of the aedeagus less dilated forward............3

-. Body on average smaller, lenght 12–14.5 mm; coloration dorsal surface darker, often blackish; discal spot of the elytra bigger, often united with the marginal spot and with that lower discal. Pronotum short and narrow, slightly wider than long. Granules of the elytra larger and irregular arranged. Shape of median lobes of the aedeagus wider and shorter forward, apex with little punctures, latero-apical crest longer and detected...*Calomera panormitana panormitana*

3. Larger body; anterior part of the dorsal surface greenish-bronze in colour. Pronotum clearly wider than long. Shape of median lobes of the aedeagus longer, latero-apical crest little short, apical punctures fairly extensive..*Calomera panormitana cretensis* n. ssp.

4. Body less wide; anterior part of the dorsal surface reddish-bronze in colour. Pronotum less transverse. Shape of median lobes of the aedeagus longer, latero-apical crest shorter, apical punctures very extensive......*Calomera panormitana cypricola*

REMARKS. The *C. aphrodisia* species group has several nomenclatural problems mainly due to designation of the locus typicus of *C. aphrodisia* and, more recently, with the use of the name *panormitana*.

Ragusa (1882), along the beach of Mondello, on the same day, collected for the first time in Sicily two different forms of taxa then classified as belonging to the genus *Cicindela* Linnaeus, 1758: the specimens with the seven-shaped elitral stain were attributed to "*Cicindela littoralis* var. *lugens* Dahl.", while two specimens were reported as "*Cicindela littoralis* var. *aphrodisia* Truqui". The figure that Ragusa provided of the "var. *Lugens* Dahl" (Ragusa, 1882: table 1 Fig. 1), as also confirmed by Cassola (1983), actually depicts a specimen of *C. aphrodisia*.

Two years later, aware of his mistake, Ragusa (1884) distinguished the "*lugens* Dejean", attributable to *C. littoralis*, from the "*lugens*" as interpreted by him (Ragusa, 1882), attributable to *C. aphrodisia*, and described the latter as a new variety ("var. *lugens* m.") (Fig. 11). Subsequently, Ragusa (1887) divided morphologically and biologically the two groups, *C. littoralis* and *C. aphrodisia*, and placed its variety lugens in the *C. aphrodisia* species group. Ragusa (1904) then described another Sicilian variety of *C. aphrodisia* ("*Cicindela aphrodisia* Baudi var. *luctuosa* Ragusa var. nov.").

Figure 9. Crete (Greece), Chania, Daratsos: locus typicus of *C. panormitana cretensis* n. ssp.

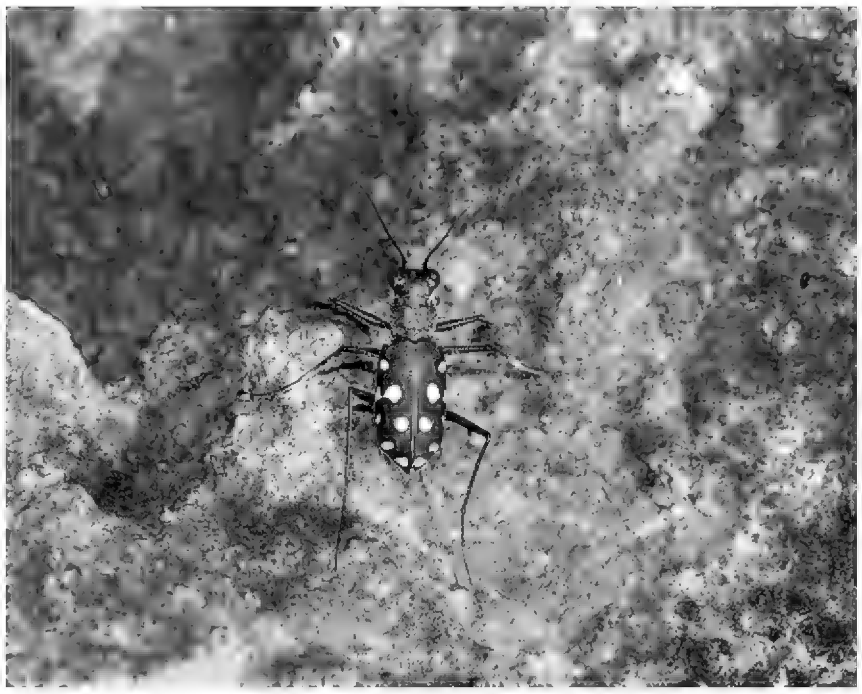


Figure 10. *Calomera panormitana cretensis* n. ssp. from Crete (Greece), Chania, Daratsos.

Finally, Ragusa (1906), following a suggestion by Horn, the then leading specialist of Cicindelidae, described the *C. aphrodisia* of Sicily as a distinct taxon (*panormitana*, locus typicus Mondello near Palermo), and renamed its two aberrations of color (*lugens* and *luctuosa*) because those names were synonyms of names already used by Dejean for the genus *Cicindela*. Moreover, he clearly reiterated that his 1882 identification of *lugens* Dejean (Ragusa, 1882), probably for misinterpretation of some information received from other colleagues, did not concern a taxon of the *C. aphrodisia* group.

The examination of the Ragusa collection confirms all the above. There are both "*lugens* Ragusa" (in the group of *C. aphrodisia*, with the typical seven-shaped elytral spot) and the "*lugens* Dejean" in the group of the *C. littoralis* (a. *lugens* Dej.). In the same entomological drawer, the systematic order follows the state of the art in force at least until 1891 with *C. aphrodisia*, and therefore also these Sicilian populations, included in the *C. aulica* group (Dejean, 1831), subsequently separated as a species distinct from Horn & Roeschke (1891; see also Ragusa, 1906).

In short, therefore, the taxon "*lugens*" as identified by Ragusa in 1882 is now *C. panormitana*. Conversely, according to Grandi (1906) and Horn (1926), the "var. *lugens* Dejean" corresponds to a variety of *C. littoralis* and this is confirmed by Porta (1923), who recorded the "var. *lugens* Dahl (Dejean)" only for Basilicata, among the Italian regions.

Cassola (1983) in a monographic work on *C. panormitana* confirms the above views. Wiesner (1992), without mentioning the sources, placed "*panormitana*" as a synonymous with "*lugens* Dejean, 1831", probably sensu Ragusa, 1882. Cassola (1999) reaffirms and extends its previous observations (Cassola, 1983), reconfirming that there is no reason to consider "*panormitana*" as a synonym of "*lugens* Dejean, 1831".

In fact, in the description of this variety (Dejean, 1831): there is no reference to the chromatic variety (seven-shaped elytral spot), characteristic of the Ragusa variety (1882); the locus typicus is Sicily and Morocco (where no species of the *C. aphrodisia* group occur); the only morphological datum indicates short elytra, while in the *C. aphrodisia* group all species and subspecies have elongated elytra.

The description of Dejean's variety is as follows (Dejean, 1831): "Cicindela littoralis *Var.* C. Lugens. *Dahl M.. Dahl m'a envoyé sous le nome del* Lugens, *des individus pris par lui en Sicilie, qui sont un peu moins allongès, et dont la couleur est presque noire en-dessus, mais qui ne me paraissent ce pendant qu'une simple variété de cette espèce. M. Goudot en a rapporté de semblables des environs de Tanger*".

The type of this variety has never been mentioned in all of this cited bibliography and is not present in the Dejean collection, kept at the Museum of Natural History in Paris, where we have researched it ("... *unfortunately I couldn't find the var. lugens*" A. Taghavian-Azari, MNHN, *in litteris*).

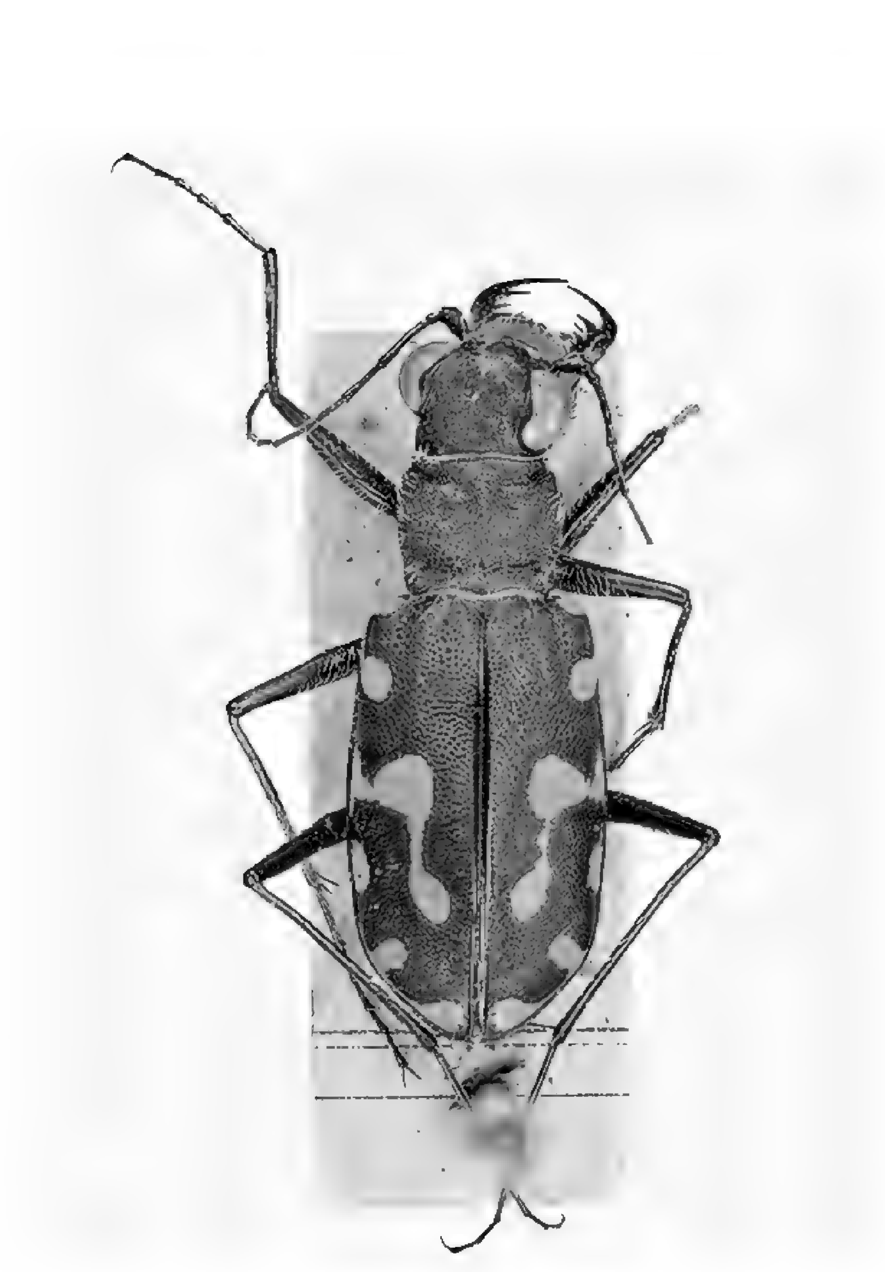


Figure 11. *Calomera panormitana panormitana* with seven-shaped elitral stains from E. Ragusa collection.

Even Ragusa (1902) had searched for this type without any result and it is not even in part of the Dejean collection kept in the Spinola collection (Giachino, 1982; R. Poggi *in litteris*).

For all these reasons, we establish here a neotypus attributable to *C. littoralis nemoralis*, because there is an exceptional need (art. 75 ICZN) for a nomenclatural stability with the following particulars: this neotype is designated with the express purpose of clarifying the taxonomic status of "*C. lugens* Dejean, 1831" and the type locality (75.3.1), to differentiate it from it from *C. aphrodisia panormitana* (75.3.2), to establish new data and a description sufficient to ensure recognition of the specimen designated (75.3.3.), considering that the type is lost or destroyed and that we have researched without finding it (75.3.4).

This neotype is consistent with what is known of the former name-bearing type from the original description (art. 75.3.5) and from the original type locality (75.3.6), following the interpretations of almost all the authors mentioned. It is deposited in the collection of the Museum of Natural History in Paris (75.3.7) (see Other examined material).

Calomera aphrodisia was described without its typical locality in a work that included material from Cyprus and Asia Minor (see Baudi di Selve, 1864, which however specified the location of the described species from Cyprus), but in these two locations there are two different populations. The typical locality, based on the original description, was established by Mandl (1981) only for Asia Minor, as accepted by all subsequent Authors. Mandl (1981) did not designate a lectotype, but reported having seen typical material present in the Kraatz collection. In the Baudi di Selve collection kept in the Museo Civico di Storia Naturale of Torino, in the typical series, there is a specimen (that seems to be attributable to *C. aphrodisia* from Asia Minor) without a label but with a small red label placed next to it.

In the original series of the entomological collection of E. Ragusa, preserved in the Institute of Environmental Biology of the University of Catania, we have selected a lectotype of *C. panormitana*, coherent with the indications of this author, while all other specimens have been labelled as paralectotypes (see Other examined material).

CONCLUSIONS

It is evident, even with this contribution, that *C. aphrodisia* is a morphologically well identifiable species, little variable, distributed along the continental coasts of Asia Minor from southern Turkey to Israel, clearly distinct from *C. panormitana* s.l.

On the contrary, in *C. panormitana* there are several widespread taxa, almost always insular, ranging from southern Turkey to Sicily, showing a greater morphological variability, probably due to allopatric speciations in progress.

They are, however, all relic populations, in constant rarefaction, with narrow ecological requirements, living only in rocky coasts, of great biogeographical importance.

Aliquò & Romano (1976) and Cassola (1983) hypothesized that the greatest expansion of these populations occurred in the upper Miocene, when the salinity crisis of the Mediterranean Sea created new and greater territorial connections, facilitating their movements. Probably, these populations have

reached Sicily, at the western limit of their distribution, through the new territories emerged during the salinity crisis, directly and without the aid of the more northern "Balkan-Apennine" bridges. This is demonstrated also by the presence in southern Italy and Sicily of animal and plant species with an Eastern Mediterranean origin showing little or no intermediate locality.

ACKNOWLEDGMENTS

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Seasonal variations of the biometric indices of *Patella rustica* Linnaeus, 1758 (Gastropoda Patellidae) from contrasted sites of the western Algerian coast

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ABSTRACT The objective of this study is the evaluation of the resistance of the bioindicative species *Patella rustica* Linnaeus, 1758 (Gastropoda Patellidae) existing in the contrasted sites of the Algerian occidental seaboard through a follow-up of the seasonal variations of biometric indices. It is based on the analysis of biometric parameters of 600 individuals of this Gastropod mollusk from five sites: Madagh (MD), Bouzedjar Harbor (BH), Ain El Turck (AT), Oran Harbor (OH), and Kristel (KR). The seasonal sampling has been carried out and measurements on the height of the shell (H), its length (L), and its total weight (TW) are taken for all the populations of *P. rustica*. The correlation of the different measurements (length-height, length-total weight, height-total weight), with the help of the power curve and following STUDENT " t " test, DUNCAN, and the ACP, reveals the development of its shell first in height, followed in second position by the length, and this for the five sites under study. Weight would thus be the parameter under analysis that evolves the least quickly as compared to the other two biometric parameters involving a generally significant difference between the five sites under study. These results confirm that the growth of this mollusk varies depending on the seasons and relies on many biotic and abiotic factors that also condition the development of the shell and the growth of limpet. This approach represents a good means for environmental evaluation that could be used in biomonitoring programs to indicate the impact of pollution in the short and long term.

KEY WORDS Algerian occidental coastline; biometric indices; Biomonitoring; *Patella rustica*.

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INTRODUCTION

The totality of the planet's ecosystems is affected one way or another by the developments of human societies and the various waste rejections that could lead to high pollution levels in the coastal marine ecosystems (Smolders et al., 2003; Rao et al., 2007; D'Adamo et al., 2008). These waste rejections of urban, agricultural, and industrial origin alter communities and affect the organisms that compose them (Boening, 1999; Viaroli et al., 2005; Warwick, 2005). The port areas, which are considered the most polluted of the coastal regions, threaten the benthic and pelagic communities

(Guerra-García & García-Gómez, 2004).Waste waters, which in many countries are not or only rarely treated, transport and dump their pollutants and organic matters into the coastal waters, thus creating eutrophisation and the bio-accumulation of toxic elements in the marine organisms whose transport all along the food chain represents a danger for human health (Boening, 1999; Daby, 2006).

The same observation is valid for Algeria. Thus, during the last decades, the coastal zones have been the site of an accelerated development and a very important demographic pressure. Around 45% of the populations are concentrated on a narrow band of the coast, in particular in the industrial and port zones like Algiers, Oran, Annaba, Arzew, and Skikda (Grimes et al., 2004). According to the same author, the population density in the coastal cities is of 281 inhabitants per square kilometer, while the national population density is of 12.2 inhabitants per square kilometer. This statement highlights the importance of having safe and healthy drinking water for such concentrated population.

Biomonitoring of water quality of the various ecosystems requires the use of sentinel organisms such as the mollusk (Long & Nilson, 1997). The limpet is a gastropod mollusk that has so far been, until now, very little explored to eco-toxicological ends. This mollusk is capable of an extraordinary adaptation to the different variations of ecological factors (Vermeij, 1973; Branch, 1981) and corresponds to the criteria of a good pollution bioindicator: sedentary, sessile, ubiquitous, easy to collect, capable of accumulating and tolerating strong concentrations of exogenous substances of anthropogenic origin (Nakhlé et al., 2006). It offers good resistance to the physic-chemical fluctuations of the environment (temperature, salinity, chemical contaminants, etc.) (Wilson, 1904; Smith, 1935; Dodd, 1955; Damen et al., 1994; Klerkx et al., 2001; Lespinet et al., 2002).

The limpets are invertebrate organisms found in masses on the rocky coasts of the intertidal and subtidal zone (Nakhlé et al., 2003). All the existing species of the genus *Patella* Linnaeus, 1758 (Gastropoda Patellidae) are limited to the North-East Atlantic and the Mediterranean Sea (Ridgway et al., 1998).

Nevertheless, the biomonitoring studies realized on this bioindicator species of the Algerian occidental coast have been performed using a biochemical approach such as biomarkers measurements, which could be very expensive (Benaissa et al., 2017). For this reason, it is necessary to develop less costly, more practical, and faster approaches based on the monitoring of morphometric parameters in this limpet.

In fact, the morphological variations can inform us of an eventual stress caused on the latter, which can be explained by the change in environmental conditions such as the availability of food and the various anthropic rejections (Beldi et al., 2012).

It is in this perspective that we have realized the follow-up of seasonal variations of the biometric indices through ponderal and linear measurements of the bioindicating species *P. rustica* Linnaeus, 1758 with the concern in the evaluation of the quality of coastal waters of the Algerian occidental coastline.

MATERIAL AND METHODS

Sampling

The choice of the sites is in relation to the different sources of pollution. Our samplings are realized at the level of five sites of the Algerian western coast (Fig. 1):

Madaghl (MD): (35°38'31.89"N; 1° 3'31.67"W), non impacted zone, which is found in a bay closed on its extremities by two small capes restricting the action of the winds. The proximity of Habibas Islands, considered as a protected area (MPA), could make of this coastal site a referential station for comparative studies.

Bouzedjar harbor (BH): (35°34'30.05"N; 1°10'6.58"W), zone that benefits from a touristic planning plan that creates an important human frequentation on its site.

Ain El Turck (AT): (35°44'35.13"N; 0°45'15.55"W), the site is situated near a desalination station.

Oran harbor (OH): (35°42'47.87"N; 0°38'40.57"W), open on the south bank of the western Mediterranean Sea. Situated at less than 200 kms from the Iberian coast, the Oran harbor constitutes the first harbor of the western Algeria.

Kristel (KR): (35°49'32.20"N ; 0°29'22.16"W), is relatively healthy and located between two capes forming the large bay of Oran, Cap Ferrat in the north and Cap Falcon in the south-east. It is situated at 28 kms from the Kristel site, and harbors a small and picturesque port where artisanal fishing is practiced.

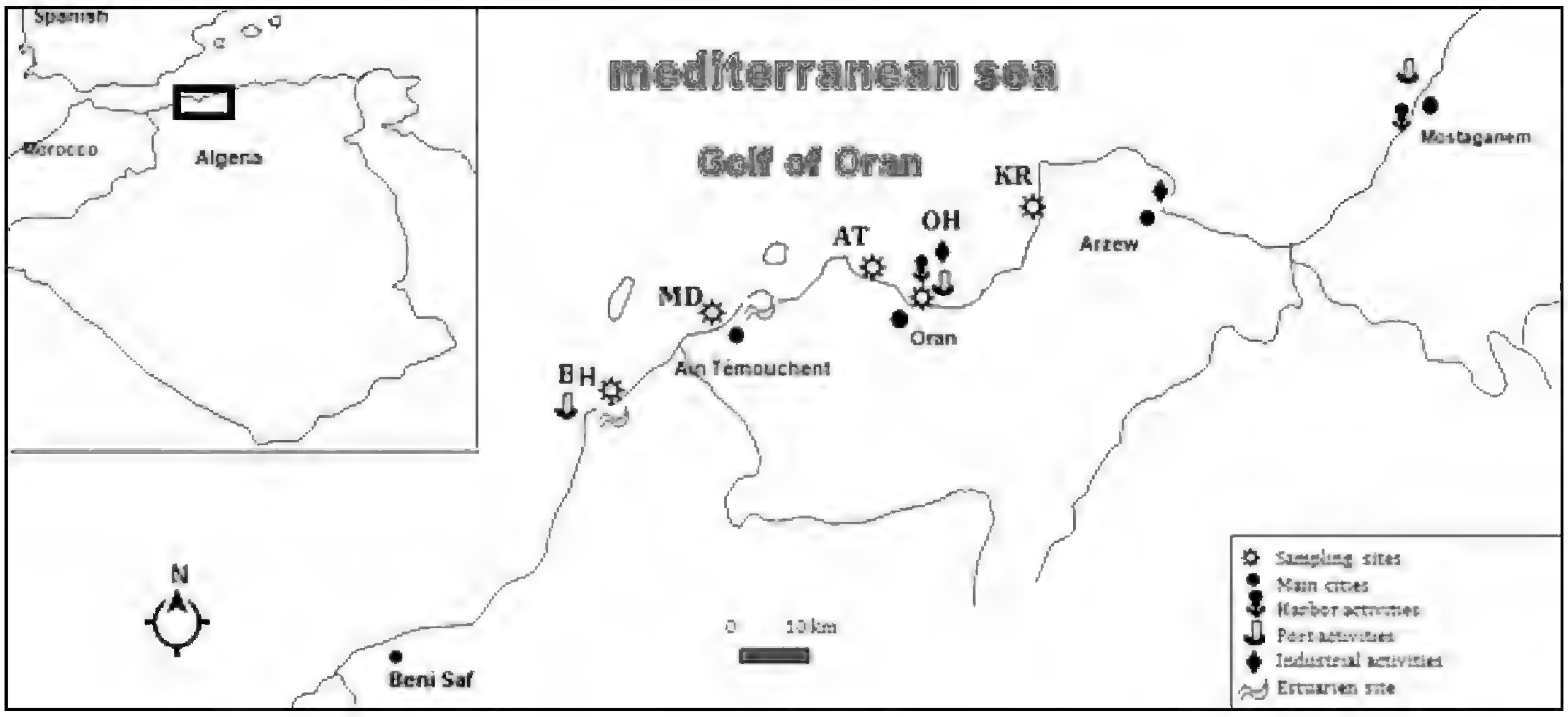

Figure 1. Study area: western Algerian coast.

Experimental sites summary

1. Kristel (KR), Ain El Turk (AT), and Madagh1 (MD): considered as relatively healthy sites with a slightly marked anthropic activity (sporadic pollution).
2. Bouzedejar harbor (BH) and Oran harbor (OH): polluted sites found on different geographical positions and substrata.

***Collection and preparation of samples of* P. rustica**

The species *P. rustica*, being different from other limpet species and very easy to see and detect to the naked eye, is sought in all favorable environments and handpicked using leverage. Six hundred specimen of *P. rustica* limpet have been collected during the four seasons of the year 2014 to 2015, 30 specimens per season per site. The limpets have been stored in a cooler at 4° C containing seawater of the ambient environment.

In the laboratory, a series of linear measurements using a vernier caliper (to 1/100 th mm), are realized, i.e., the length of the shell (L), the height of the shell (H), and the total weight of the specimen (TW) (hard weight and soft weight) with the help of a precision scale (to 1/100 th g).

The interpretation of these different measurements are correlated with a power curve of the form y = axb (Myers, 1986), which is transformed into a logarithmic function of form: log y = log a + b log x. This transformation is the simplest method to linearize the relationship, stabilize the variances and normalize the variables (Myers, 1986). It is admitted that the variables measured are without significant errors, since the method of calculation adopted is that of the least squares.

Statistica 7.0 has been used for inter-sites comparison biological parameters of *P. rustica* using the DUNCAN test; $P<0.05$), and ACP for the inter-sites and seasonal comparisons, but also the different biometric parameters of the various groups of *P. rustica*.

RESULTS AND DISCUSSION

The biometric parameters show minima and a maxima values respectively for the length of the shell comprised between 19 mm and 36 mm, for the height of the shell (5 mm to 14 mm), and for the total weight of the values of the order of 1.21 g to 7.84 g.

The means and typical gaps are represented in Table 1 as well as the marked significance following the DUNCAN test ($P<0.05$) between the parameters considered annually and inter-sites. The Annual and seasonal allometric results for *P. rustica* populations are showed in Tables 2, 3, 4, and 5.

The analysis of these tables reveals for all the results related to the relation length-height a strong correlation for three seasons (Winter - Spring - Summer), which order varies from 72% to 93% ($P<0.05$) (Table 3) for the five sites considered, whereas Autumn is attributed the lowest values (67% to 77%). These values witness a good correlation of the two linear parameters (L–H). We see a good autumnal correlation of 60% and 70%, going up to a strong correlation of the order of 94% for the other three seasons.

The two parameters of L and H and following test "T" show a minor allometry (for the four seasons and for the five sites), which means that L grows more slowly than H.

The annual study of the coupled interaction of TW–L reveals a strong correlation between these latter two with a coefficient of 0.74 and 0.81 ($P<0.05$) for BH, between 0.54 and 0.91 for KR, 0.68 and 0.96 for AT, 0.77 and 0.90 for MD, 0.69 and 0.90 finally for OH (Table 4). As for the preceding two parameters, the correlation between TW and L varies between strong in autumn to very strong for the other three seasons. Factor b marks a significant minor allometry and sometimes on for the winter, summer, and autumn seasons ($b<2.5$), which means a less important development of TW than the L of the shell. In addition, factor b marks an isometric in spring ($b>2.5\approx3$), which explains that the TW evolves at the same speed as the L of the shell apart from AT (Baibbat & Abid, 2015).

Finally, the co-evolution of TW and H has in turn revealed a correlation coefficient varying between 0.64 and 0.87 for BH ($P<0.05$), from 0.64 to 0.91 for KR, 0.52 to 0.90 for AT, 0.70 to 0.90 for MD and finally 0.50 to 0.93 for OH (Table 5). Test T reveals significance between the two parameters and a minor allometry for all the stations and during the whole year, which shows that the H grows faster than TW.

The Morphometric parameters measured in the limpet in the five sites (BH, KR, AT, MD, OH) have been integrated in a multi-varied analysis so as to detect the models of variation. The correlation circle formed by F1 and F2 indicates an axis that shows 88.7% of the total information. The two main components PC1 and PC2 have been identified as representing respectively 33.01% and 18.62% of the total variance.

PC1 is negatively correlated with all parameters. PC2 is positively correlated with the three parameters (L, H, TW) of MD, BH and also with the L parameters of OH and AT. On the contrary, PC2 is negatively correlated with the three parameters (L, H, TW) of KR and also (H and TW) of the OH and AT.

There are of the correlations between the different sampling seasons and F1 and F2 shown 98% of the total information. They represent respectively 96.26% and 1.57% and they also give a good description of most of the studied parameters. PC1 is

Sites / Parameters	BH	KR	AT	MD	OH
lengths	27.78±2.83^{a}	26.16± 2.38^{b}	24.66± 3.30^{c}	23.91± 3.46^{c}	27.09± 4.23^{a}
height	10.03±1.80^{a}	8.63±1.30^{b}	8.58± 1.71^{b}	8.61± 1.72^{b}	8.77± 1.68^{b}
total weight	3.57± 1.11^{a}	3.91± 0.84^{b}	3.28± 0.83^{cd}	3.07± 0.95^{d}	3.54± 1.46^{ac}

Table 1. Averages and standard deviations of the lengths, height, and total weight of limpets collected seasonally at the five study sites.

STATIONS	EQUATION	N	R	ALLOMETRY TEST	ALLOMETRY
BH	$L=0.0608H^{1.5336}$ $P=0.1812L^{1.2815}$ $P=0.0009H^{2.4757}$	120 120 120	0.759 0.5809 0.6995	** ** **	Minorante Minorante Minorante
KR	$L=8.55H^{0.5195}$ $W=0.0083L^{1.8829}$ $W=0.2654H^{1.2444}$	120 120 120	0.7045 0.6638 0.7569	** ** **	Minorante Minorante Minorante
AT	$L=7.3001H$ $W=0.0153L^{1.6705}$ $W= 0.326H^{1.0686}$	120 120 120	0.6766 0.768 0.6613	** ** **	Minorante Minorante Minorante
MD	$L=7.1308H^{0.5625}$ $W=0.0084L^{1.8522}$ $W=0.2921H^{1.0836}$	120 120 120	0.6468 0.785 0.5492	** ** **	Minorante Minorante Minorante
OH	$L=8.3932H^{0.5388}$ $W=0.0016L^{2.3094}$ $W=0.0985H^{1.6263}$	120 120 120	0.4472 0.7691 0.5876	** ** **	Minorante Minorante Minorante

Table 2. Overall allometric equations between length, height and total weight of *P. rustica* in the five stations (BH), (KR), (AT), (MD), and (OH) during the four seasons of the year. N: Number of individuals; R: Coefficient of correlation of regression equations; **: Significant Student Test ($P<0.05$).

STATIONS	SEASONS	EQUATION	N	R	ALLOMETRY TEST	ALLOMETRY
BH	Winter	$L= 8.2528H^{0.5239}$	30	0.8012	**	Minorante
	Spring	$L= 8.9992H^{0.494}$	30	0.8325	**	Minorante
	Summer	$L= 7.4993H^{0.5585}$	30	0.8017	**	Minorante
	Autumn	$L= 8.784H^{0.5123}$	30	0.6838	**	Minorante
KR	Winter	$L= 7.8476H^{0.5693}$	30	0.9145	**	Minorante
	Spring	$L= 12.649H^{0.3573}$	30	0.8619	**	Minorante
	Summer	$L= 7.12H^{0.5776}$	30	0.8828	**	Minorante
	Autumn	$L= 9.2642H^{0.4833}$	30	0.6926	**	Minorante
AT	Winter	$L= 7.3911H^{0.6067}$	30	0.9166	**	Minorante
	Spring	$L= 8.4299H^{0.5092}$	30	0.9253	**	Minorante
	Summer	$L= 6.3764H^{0.6009}$	30	0.9012	**	Minorante
	Autumn	$L= 7.7838H^{0.5146}$	30	0.7649	**	Minorante
MD	Winter	$L= 8.1148H^{0.5579}$	30	0.9085	**	Minorante
	Spring	$L= 5.9738H^{0.6414}$	30	0.9225	**	Minorante
	Summer	$L= 7.113H^{0.5378}$	30	0.936	**	Minorante
	Autumn	$L= 7.6723H^{0.4996}$	30	0.7755	**	Minorante
OH	Winter	$L= 5.767H^{0.706}$	30	0.7244	**	Minorante
	Spring	$L= 12.446H^{0.423}$	30	0.9375	**	Minorante
	Summer	$L= 7.017H^{0.6345}$	30	0.9087	**	Minorante
	Autumn	$L= 8.7414H^{0.4569}$	30	0.6767	**	Minorante

Table 3. Annual allometric equations between shell length of *P. rustica* and its height in the five stations (BH), (KR), (AT), (MD), and (OH) during the study year. N: Number of individuals; R: Coefficient of correlation of regression equations; **: Significant Student Test (P <0.05).

STATIONS	SEASONS	EQUATION	N	R	ALLOMETRY TEST	ALLOMETRY
BH	Winter	$W= 0.0019L^{2.2695}$	30	0.7856	**	Minorante
	Spring	$W= 0.0004L^{2.769}$	30	0.7968	**	Isometric
	Summer	$W= 0.0012L^{2.3496}$	30	0.8131	**	Minorante
	Autumn	$W= 0.0021L^{2.2566}$	30	0.7458	**	Minorante
KR	Winter	$W= 0.0094L^{1.8035}$	30	0.8109	**	Minorante
	Spring	$W= 0.0002L^{2.9906}$	30	0.9122	**	Isometric
	Summer	$W= 0.011L^{1.8068}$	30	0.8916	**	Minorante
	Autumn	$W= 0.0124L^{1.7878}$	30	0.543	**	Minorante
AT	Winter	$W= 0.0104L^{1.7746}$	30	0.8775	**	Minorante
	Spring	$W= 0.0063L^{1.934}$	30	0.944	**	Minorante
	Summer	$W= 0.0023L^{2.3162}$	30	0.9603	**	Minorante
	Autumn	$W= 0.0062L^{1.9393}$	30	0.6781	**	Minorante
MD	Winter	$W= 0.0745L^{1.1778}$	30	0.8573	**	Minorante
	Spring	$W= 0.0003L^{2.9155}$	30	0.9039	**	Isometric
	Summer	$W= 0.0018L^{2.3202}$	30	0.8712	**	Minorante
	Autumn	$W= 0.0189L^{1.5869}$	30	0.7744	**	Minorante
OH	Winter	$W= 0.0015L^{2.3269}$	30	0.8515	**	Minorante
	Spring	$W= 0.0002L^{2.9304}$	30	0.8914	**	Isometric
	Summer	$W= 0.0003L^{2.7545}$	30	0.9037	**	Isometric
	Autumn	$W= 0.0038L^{2.1056}$	30	0.6954	**	Minorante

Table 4. Annual allometric equations between shell length of *P. rustica* and total weight in the five stations (BH), (KR), (AT), (MD), and (OH) during the study year. N: Number of individuals; R: Coefficient of correlation of regression equations; **: Significant Student Test (P <0.05).

STATIONS	SEASONS	EQUATION	N	R	ALLOMETRY TEST	ALLOMETRY
BH	Winter	$W=0.1469H^{1.3794}$	30	0.8472	**	Minorante
	Spring	$W=0.0974H^{1.5712}$	30	0.8751	**	Minorante
	Summer	$W=0.0927H^{1.4659}$	30	0.8136	**	Minorante
	Autumn	$W=0.2055H^{1.3026}$	30	0.6472	**	Minorante
KR	Winter	$W=0.3062H^{1.1385}$	30	0.9117	**	Minorante
	Spring	$W=0.3449H^{1.1477}$	30	0.9072	**	Minorante
	Summer	$W=0.3227H^{1.1224}$	30	0.9105	**	Minorante
	Autumn	$W=0.3749H^{1.1277}$	30	0.6406	**	Minorante
AT	Winter	$W=0.3397H^{1.1054}$	30	0.8479	**	Minorante
	Spring	$W=0.3819H^{0.9946}$	30	0.8909	**	Minorante
	Summer	$W=0.1591H^{1.4204}$	30	0.9015	**	Minorante
	Autumn	$W=0.3281H^{1.0038}$	30	0.5249	**	Minorante
MD	Winter	$W=0.799H^{0.7008}$	30	0.886	**	Minorante
	Spring	$W=0.0498H^{1.9405}$	30	0.8979	**	Minorante
	Summer	$W=0.1484H^{1.3145}$	30	0.9049	**	Minorante
	Autumn	$W=0.4199H^{0.8563}$	30	0.7007	**	Minorante
OH	Winter	$W=0.0448H^{1.9585}$	30	0.8766	**	Minorante
	Spring	$W=0.2972H^{1.2928}$	30	0.9093	**	Minorante
	Summer	$W=0.052H^{1.8632}$	30	0.9332	**	Minorante
	Autumn	$W=0.338H^{0.9993}$	30	0.5079	**	Minorante

Table 5. Annual allometric equations between shell height of *P. rustica* and total weight in the five stations (BH), (KR), (AT), (MD), and (OH) during the study year. N: Number of individuals; R: Coefficient of correlation of regression equations; **: Significant Student Test ($P < 0.05$).

negatively correlated with the two cold seasons, winter and autumn. PC2 is positively correlated with the hot seasons, spring and summer.

DISCUSSION

The study of the biological parameters taken into account in this study highlights an excellent correlation of biometric relations for the five sites of study (Fig. 1), and also for winter, spring, and summer, whereas in autumn this correlation coefficient indicates the lowest values.

This variability could be linked to different factors, whether biotic and/or abiotic (Grimes et al., 2004).

The good development of limpets and the good correlation of the three parameters (length, height, total weight) at the polluted sites (OH, BH) could be due to the fact that the stations are situated near the urban waste rejection seen as very rich in nutrient salts, which encourages the development of phytobenthos on the medio-littoral and supra-littoral shelf with a strong concentration in spring when phytoplancthonic bloom is at its highest level. This explains the isometric development between length and weight. Generally, temperate limpets grow more rapidly in summer due to the increased abundance of food (Brêthes et al., 1994; Vat, 2000). In the present study, the result shows that there would be a good correlation in the summer and spring period of the whole of the *P. rustica* populations. For this reason, the marked R^2 in summer for all the stations under study is very good. According to Davies (1969), *P. rustica* occupies the superior intertidal zone whereas *P. caerulea* Linnaeus, 1758 and *P. ulyssiponensis* Gmelin, 1791 colonize the inferior part of this zone. Grimes et al. (2004) specify that *P. rustica* settles mainly in the inferior medio-olittoral where it is found in abundance and where it takes its food resources. This food contributes widely to its physiology development (growth, reproduction) and exerts a direct effect on the speed and duration of gametogenesis phenomena (Lubet, 1980). This explains the slightly important weight obtained in autumn (a period weak in nutrients, but also a period marked by reproduction for *P. rustica* from July to December) (Othaitz, 1994), including

a correlation of the order of 60%, instead of 80% to 96% for the other seasons.

These results are corroborated by Frehi et al. (2007) and Beldi et al. (2012), who approve that the polluted sites are very rich in phytoplankton, which allows *P. rustica* to be a grazing species. The algae cover and the floristic composition play a major role in the abundance of herbivorous (Hereu, 2004).

The *P. rustica* shells present an allometry in their growth in length and in height, because they grow more in height than in length. Our species is considered to be using a strategy of energy conservation due to its unstable environment and its limited food resources. To this effect, it encourages the development of its shell in height in order to be able to store water and thus hydrate itself during prolonged emersion periods (Sokolova & Pörtner, 2003; Prusina et al., 2014).

Moreover, the growth of the shell and of the total weight of our samples is observed at the level of all the chosen sites, whether they are impacted or not. The biometric relations done on *P. rustica* specimens taken from MD, KR, and AT show a correlation which is as important as those taken from the two harbors (OH and BH). This indicates that the limpets of the coastal sector and the two harbors evolve in the same manner and that pollution does not impact on the specimens (same biological equilibrium).

CONCLUSIONS

This study, based on the biometry of *P. rustica*, was realized in order to evaluate the evolution of the latter from the point of view of total weight, and anteroposterior length of the shell, as well as its height at the level of the different sites having a variable pollution rate. We have shown evidence that this species has the capacity to develop in different environments and that it has shown to be a resilient and resistant species. Following these results, *P. rustica* evolves in its environment given the growth of these biological parameters taken into consideration, and this despite the environment.

Finally, it would be interesting to enlarge the spectrum to several other sampling points of this gastropod mollusk *P. rustica* for a wider and complementary study of these biometric parameters.

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Observation of feeding habit of the Asian water monitor, *Varanus salvator* (Laurenti, 1768) (Squamata Varanidae) on a Asian toad, *Duttaphrynus melanostictus* (Schneider, 1799) (Anura Bufonidae) in Thailand

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ABSTRACT The feeding habit of the Asian water monitor, *Varanus salvator* (Laurenti, 1768) (Squamata Varanidae) in Thailand indicated that this species is carnivorous and scavenger. Here, we describe an observation of an Asian water monitor on an Asian toad, *Duttaphrynus melanostictus* (Schneider, 1799) (Anura Bufonidae) in urban areas of Central Thailand. Feeding habit data of an Asian water monitor is provided here.

KEY WORDS Asian water monitor; *Varanus salvator*; Asian toad; *Duttaphrynus melanostictus*; ecology.

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INTRODUCTION

The Asian water monitor, *Varanus salvator* (Laurenti, 1768) (Squamata Varanidae) is the largest monitor in Thailand and the second largest lizard in the world (Shine et al., 1996). In Thailand, the Asian water monitor can be found in many ecosystems from hill streams, mangroves, national parks, to urban ecosystems. Habitat of this species is the semiaquatic ecosystem. The microhabitat of the species was thermally stable and the species also used burrows to control the body temperature (Shine et al., 1996). The Asian water monitor is the most widespread species among all monitor lizards. Distribution range of this species extends from India Subcontinental to South East Asia, Sunda Islands, and Moluccas (Böhme, 2003; Gaulke & Horn 2004; Koch et al., 2007, 2010).

The current status of the species can be separated into following subspecies according to Koch et al. (2010). Namely, *V. salvator salvator* from Sri Lanka, *V. salvator bivittatus* (Kuhl, 1820) from Indonesia, type locality Java, *V. salvator andamanensis* Deraniyagala, 1944 from Andaman Islands, *V. salvator macromaculatus* Deraniyagala, 1944 from Thailand, Peninsula Malaysia, Vietnam, southern China, Hainan, Sumatra, and Borneo and smaller off-shore islands.

Feeding habit and reproductive biology of Asian water monitor were reported in many countries, especially in Sumatra, Indonesia. Shine et al. (1998) reported that the monitor lizard can eat a wide variety of prey, including vertebrates (e.g., rats, chickens) and invertebrates (e.g., insects, crabs). Fitzsimons & Thomas (2016) reported that the Asian water monitor feeds on many types of car-

casses such as the Bornean Bearded Pig, *Sus barbatus barbatus* Müller, 1838 (Mammalia Suidae) in Borneo, and the Banded pigs, *Sus scrofa vittatus* Boie, 1828 in Sumatra, *Sus ahoenobarbus* Huet, 1888 in Philippine (Gaulke, 1992), and food scraps from the rubbish bins of households and restaurants (Kulabtong & Mahaprom, 2015).

The Asian water monitor, *V. salvator*, is carnivore and eats different types of food. They are known to eat fish, frogs, rodents, birds, crabs, snakes, turtles, young crocodiles, crocodile eggs, chickens, ducks, insects, carcasses, and garbage (Whitaker, 1981; Sprackland, 1992; Uyeda, 2009; Das, 2010). Reproduction of the monitor lizard occurs throughout the whole year, with lower intensity in drier months. The monitor lizard can produce multiple clutches of 6–17 eggs each year. In Thailand, the biological data of the Asian water monitor, *V. salvator* are poorly known, especially in the urban ecosystem.

MATERIAL AND METHODS

This study into the behavior of the Asian water monitor related to eating the Asian toad (*Duttaphrynus melanostictus*) was the first formal report in Thailand found at the Dusit Zoo in Bangkok, the Central region of Thailand. The area of the Dusit Zoo covers 22.7 hectares. This area is considered as the green area of the city ecological system of Bangkok. On 20 June, 2017, at 3.20 p.m., a newborn Asian water monitor was found. Its size, measured from the top of the head to the end of the tail, was of 30 centimeters. It was observed that while this water monitor was walking to find food at the nook of the floor cement, it held an Asian toad in its mouth up from such nook and then it managed to thrash the Asian toad back and forth, left and right down to the floor. This took about 3 minutes before it swallowed the toad.

DISCUSSION AND CONCLUSIONS

Regarding the biological aspects, in the family of Varanids, Pianka (1997) stated that the animal, when it is still young, tends to live in a tree rather than living on the floor because this would prevent it from being hunted. Then, when it is time to find

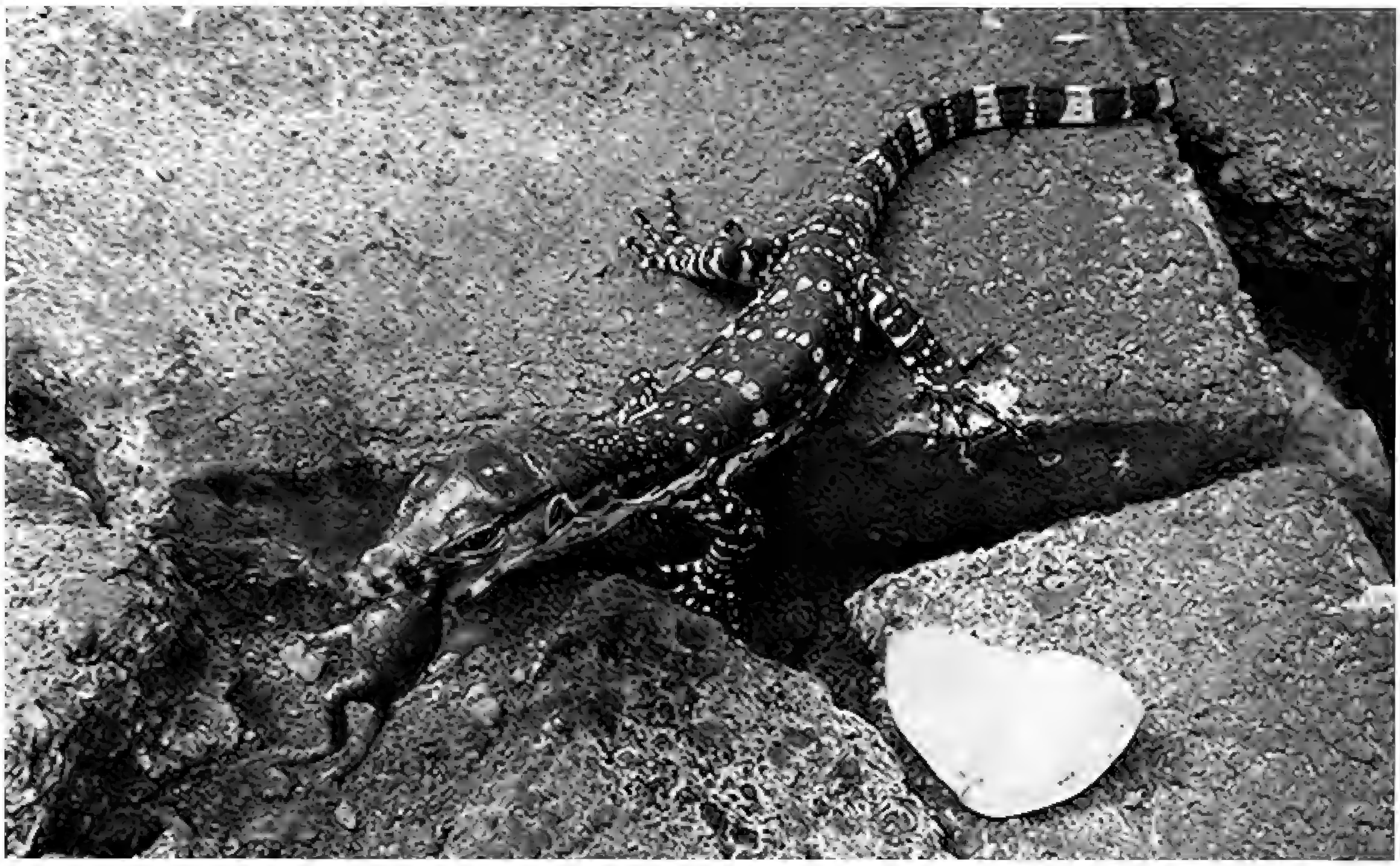

Figure 1. Asian water monitor, *Varanus salvator* (Laurenti, 1768) with captured Asian toad, *Duttaphrynus melanostictus* (Schneider, 1799).

food, it would come down from the tree to the floor. The kinds of food of the young water monitor include young fish, young frog, young green frog, young worm. Therefore, the observation of the young water monitor eating a young toad is interesting because the water monitor has protein or enzymes that can resist toxin of the toad. There are also research reports of Karunarathna et al. (2017) and Whitaker (1981), reporting on the kinds of food of the water monitor and Bengal monitor living around the rain forest of Bangladesh and Sri Lanka and on the finding of the Bengal monitor (*Varanus bengalensis*) in Sri Lanka, eating toads the same way as in this study.

The body of the toad consists of paratoid glands, which look like the shape of an egg or an ellipse and are located behind the eyes. It produces a substance called "Bufotoxin", which looks like milk and smells pungent. In addition, its skin also releases several kinds of substances that have biological properties that could lead to high blood pressure, neurotoxicity, cardiotoxicity, haemolysis, and it can stimulate sleep (Dutta & Das, 2013). It is reported that toad's toxin could irritate skin and had lead to illness and death of human beings in Laos and Taiwan eating these toads (Khan, 1982; Mercy, 1999).

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A revision of the Mediterranean Raphitomidae (Gastropoda Conoidea), 6: on the *Raphitoma corbis* (Potiez et Michaud, 1838)

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ABSTRACT In this paper, the authors deal with *Raphitoma corbis* (Potiez et Michaud, 1838) (Gastropoda Conoidea), a poorly-known taxon differently interpreted over time, by fixing a neotype in order to stabilize the nomenclature because the type material has been lost.

KEY WORDS Mollusca; Gastropoda; Conoidea; neotype; Mediterranean Sea; Taxonomy.

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INTRODUCTION

The Raphitomidae Bellardi, 1875 are currently considered a well supported clade of the Conoidea (Bouchet et al., 2011). The superfamily Conoidea, with over 300 genera and 4,000 recognised species, but probably over 12,000 extant species (Bouchet, 1990; Tucker, 2004), represents the largest radiation of the entire phylum Mollusca. In a work on the phylogeny of the group based on a cladistic analysis of foregut morphology, Taylor et al. (1993) have highlighted the rampant homoplasy in the characters of shell and radula in conoideans. Accordingly, they have rearranged most of the conoideans into two families: Conidae, comprising Coninae and 4 subfamilies traditionally considered as "turrids", and Turridae s.s., including some of the traditional "turrids". More recently, Puillandre et al. (2008) and Bouchet et al. (2011), have provided a major update of conoidean classification based on DNA phylogeny. Although a larger taxonomic coverage would be desirable to further stabilize the molecular phylogeny, however, the position of the Raphitomidae as a clade of the Conoidea is sufficiently supported.

The taxon Raphitomidae is based on the genus *Raphitoma* Bellardi, 1847 which was introduced comprising 30 fossil and Recent species (Bellardi, 1847: 85), previously classified in various genera (such as *Pleurotoma* Lamarck, 1799 and *Clathurella* Carpenter, 1857). Among the modern authors, Nordsieck (1977) listed 30 european species of Raphitomidae plus several subspecies and varieties. In the revision of the mediterranean Raphitomidae that we are currently carrying out, we estimated about 50 mediterranean species, some of which are still to be described.

MATERIAL AND METHODS

Our approach was exclusively based on shell morphology due to the almost total lack of anatomical data.

Specimens were studied from materials housed inseveral European museums and from private collections (see Abbreviations and Acronyms). Unless

otherwise stated, the shells originated after sorting bioclastic sand samples collected between 0-80 m depth.

SEM images were taken by Andrea Di Giulio at the "LIME" (Interdepartmental Laboratory of Electron Microscopy - Roma Tre University). Light photographs were taken (if not otherwise stated) by Stefano Bartolini using a Canon EOS 400D digital photocamera, with standard objective 50 mm + adapted objectives (25 and 12.5 mm) for a 16 and 8 mm vintage cine camera and by Riccardo Giannuzzi Savelli using a Canon EOS 45D mounted on a Kyowa binocular microscope, assembled with Helicon Focus 6 software and background removed with Clipping Magic.

ABBREVIATIONS AND ACRONYMS. HUJ: Hebrew University of Jerusalem (Israel); MCZR: Museo Civico di Zoologia (Roma, Italy); SMNH: Swedish Museum of Natural History (Stockholm, Sweden); CRO: Paolo Crovato (Napoli, Italy); MAR: Alessandro Margelli (S. Maria a Monte, Italy); MON: Giuseppe Monti (Brisighella, Italy); NOF: Italo Nofroni (Roma, Italy); OCC: Rosario Occhipinti (Ragusa, Italy); PAG: Attilio Pagli (Vinci, Italy); PAO: Paolo Paolini (Livorno, Italy); PAL: Alberto Palmeri (Palermo, Italy); PEN: Anselmo Peñas (Vilanova i la Geltrù, Spain); PIS: Michele Pisanu (Quartu S. Elena, Italy); PUS: Francesco Pusateri (Palermo, Italy); RUF: Stefano Rufini (Anguillara, Italy); RUG: Ruggero Ruggeri† (Roma, Italy); SER: Gabriele Sercia (Palermo, Italy); SOS: Maurizio Sossu (Genova, Italy); d: diameter; h: height; sh: shell/s; Std: standard deviation (DS); w: widht.

RESULTS

Systematics

Citation of unpublished names is not intended for taxonomic purposes.

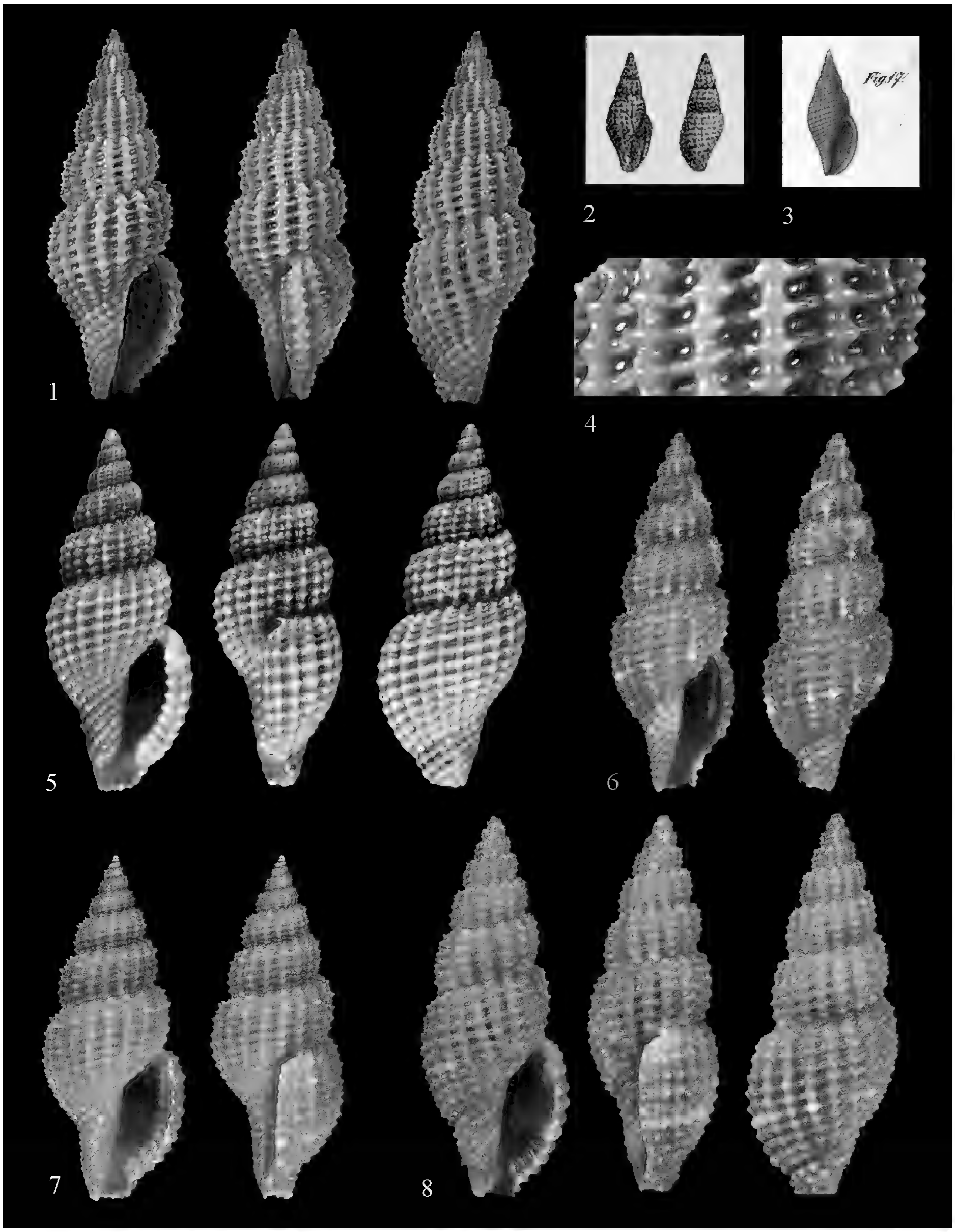
Classis GASTROPODA Cuvier, 1795
Subclassis CAENOGASTROPODA Cox, 1960
Ordo NEOGASTROPODAWenz, 1938
Superfamilia CONOIDEA Fleming, 1822
Familia RAPHITOMIDAE Bellardi, 1875
Genus *Raphitoma* Bellardi, 1847

TYPE SPECIES. *Pleurotoma hystrix* Cristofori et Jan, 1832 (nomen nudum, validated by Bellardi, 1847 as "*Pleurotoma histrix* Jan.") by subsequent designation (Monterosato, 1872: 54).

Raphitoma corbis (Potiez et Michaud, 1838) [*Pleurotoma*] Figs. 1, 2; 4–22

Pleurotoma corbis Potiez et Michaud, 1838: 444 (sp. 8)
Pleurotoma corbis Desmoulins, 1842: 63 (as synonym of *Pleurotoma purpurea*)
Pleurotoma corbis Reeve, 1843, pl. 16 sp. 136 (as synonym of *Pleurotoma purpurea*)
Pleurotoma corbis Potiez, 1844: 52, pl. 35 figs. 1,2
Pleurotoma corbis Bellardi,1847: 87 (as synonym of *Pleurotoma purpurea*)
Pleurotoma corbis Jay, 1850: 325 (as synonym of *Pleurotoma purpurea*)
Pleurotoma corbis var. *atra* Monterosato, 1878: 106 (*nomen nudum*)
Pleurotoma corbis var. *cinerea* Monterosato, 1878: 106 (nomen nudum)
Pleurotoma corbis var. *nebulosa* Monterosato, 1878: 106 (*nomen nudum*)
Pleurotoma corbis var. *flavida* Monterosato, 1878: 106 (*nomen nudum*)
Pleurotoma corbis var. *major* Monterosato, 1878: 106 (*nomen nudum*)
Pleurotoma corbis var. *minor* Monterosato, 1878: 106 (*nomen nudum*)
Pleurotoma corbis var. *textilis* Monterosato, 1878: 106 (*nomen nudum*)
Pleurotoma corbis B.D.D, 1883: 91 (as synonym of *Pleurotoma laviae*)
Pleurotoma corbis Tryon, 1884: 335 (as synonym of *Pleurotoma purpurea*)
Clathurella corbis Locard, 1886: 114
Clathurella corbis Locard, 1891a: 6
Clathurella corbis Locard, 1891b: 106
Clathurella corbiformis Locard, 1892: 65 (*emendatio invalida*)
Pleurotoma corbis Carus, 1893: 425 (as synonym of *Pleurotoma purpurea*)
Philbertia corbiformis Nordsieck, 1968: 177 (As synonym of *Philbertia densa*)
Raphitoma (*Philbertia*) *corbis* Nordsieck, 1977: 57, pl.18 fig. 143

ORIGINAL DESCRIPTION. *Pleurotoma corbis* Potiez, 1838. Gal. Moll. Douai 1: 444, sp. 8. La Méditerranée. Potiez, 1844, Gal. Moll. Douai, Atlas (1844) p. 52, pl. 35, figs. 1, 2.



Figures 1–8. Shells of *Raphitoma corbis* (Potiez, 1838). Fig. 1: Neotype, Palermo, Italy (MCZR-M-16806), h: 11.6 mm; Fig. 2: original drawing by Potiez (1838); Fig. 3: original drawing by Philippi (1844) of *Raphitoma laviae*; Fig. 4: Neotype, details of the sculpture. Fig. 5: Roussillon (France), h: 12.3 mm (MNHN, labelled by Locard as *P. atropurpurea*; Fig. 6: Isola delle Femmine (Italy), h: 12.1 (slender form); Fig. 7: Golfo di Termini Imerese (Italy), h: 9.1 (broad form); Fig. 8: Isola delle Femmine (Italy), h: 9.4 mm (with 22 axial ribs).

Potiez, 1838: "*Pleur. Testa fusiformi, fulva, longitudinaliter costata, transversimque regulariter sulcata; sulcis transversis longitudinalibusque decussata; anfractibus gradatis, parte superiore angulatis; sutura profunda; apertura elongata; cauda longiuscula, extus sulcata, nodis laevibus cincta; columella valde arcuata. Longuer.... 4–5 mil diametre dernière tour 1–1,5 mil. La Méditerranée*".

TYPE MATERIAL. Neotype is here designed from MCZR-M-16806 labelled "*Ph. atropurpurea*" Figs. 1, 4).

TYPE LOCALITY. Palermo (1886).

EXAMINATED MATERIAL. The type material and the following one: Spain. Alboran, 3 sh (PEN); Costas Mijas (Malaga), 4 sh (PEN); Begur (Girona), 1 sh (PEN); Cabo de Palos, -30 m, 1 sh (PUS).

France. St. Raphael, 1 sh (PUS).

France, Corse. Bastia, 2 sh (PUS).

Italy. Capo Pino (Sanremo), 1 sh (RUF); Riva Trigoso (Genova), 1 sh (SOS); Baratti (Livorno), 2 sh (PAO); 1 sh (NOF); Livorno, 1 sh (MON); Castiglioncello (Livorno), 1 sh (MAR), 1 sh (PAO); Punta Ala, 2 sh (PAG); Capraia Island, 1 sh. (PAG); Santa Marinella (Roma), 1 sh (RUG); Nettuno (Roma), 1 sh (OCC); Terracina (Latina), 1 sh (PAG); Civitavecchia, 1 sh (RUF); Napoli, 2 sh (PUS); Puolo (Napoli), 2 sh (RUF); Procida Island, 1 sh (PAL); Punta Pioppeto (Procida Isl.) -6 m, 1 sh (CRO); Ponza Island -35 m, 1 sh (PAG).

Sardinia. Poetto (Cagliari), 1 sh (PIS).

Sicily. Palermo, 7 sh (PUS), 12 sh (HUJ coll. Coen lot 8079, sub nomine *Philbertia purpurea*; Golfo di Palermo, 13 sh (PUS); Isola delle Femmine (Palermo), 3 sh (PUS), 5 sh (SER); S. Vito Lo Capo (Trapani), 7 sh (PUS); Isola Lachea (Acitrezza, Catania), 9 sh (SMNH, lot 73197D).

DESCRIPTION. In square brackets the data of the neotype. Shell fusiform-acute, of medium size for the genus, height 8–12 mm, mean 9.75 (DS: 1.10) [11.6], width 3.4–4.5 mm, mean 3.94, DS: 0.32 [4.3], h/d: 2.18–2.88 (mean 2.47), DS 0.15 [2.68].

Protoconch multispiral of 2.4 convex whorls, heigth 395 µm, width 347 µm, protoconch I of 1 whorls, width 164 µm, covered by thin cancellations, protoconch II with a diagonally cancellate sculpture starting after a short zone under the suture with fine curved axial threads. The last whorl with very short and weak keel before the onset of the teleoconch. Protoconch-teleoconch boundary strongly flexuose, opisthocline.

Teleoconch of 6–8, mean 7 [7.5], slightly convex whorls and scaled, thin, suture incised, sculpture prominent. No microgranules in the surface. Axial sculpture of 14–22 mean 18.2, Std: 1.86 [19] slightly opisthocline, equidistant ribs, and interspaces larger than the ribs. The ribs are more evident than the cordlets.

Spiral sculpture 6–7 [7] cordlets above the aperture. Sometime one or two additional weak cordlets can be present next the suture. Cancellation rectangular, with strong and elongated tubercles at the intersection of axials and spirals. Subsutural ramp narrow.

Columella simple, slightly sinuous anteriorly, gently angled posteriorly. The siphonal channel is short and wide at the end. Outer lip with 9–14 strong inner plicate denticles, mean 10.8 [10]. Sometime the last denticle can be double. Siphonal fasciole with 7–9, mean 8, strong nodulose cords [9]. Colour from firm brown to light hazel, rarely even some costae are equally clear. Sometime in the last whorl there is a lighter cordlet on the suture.

Soft parts: unknown.

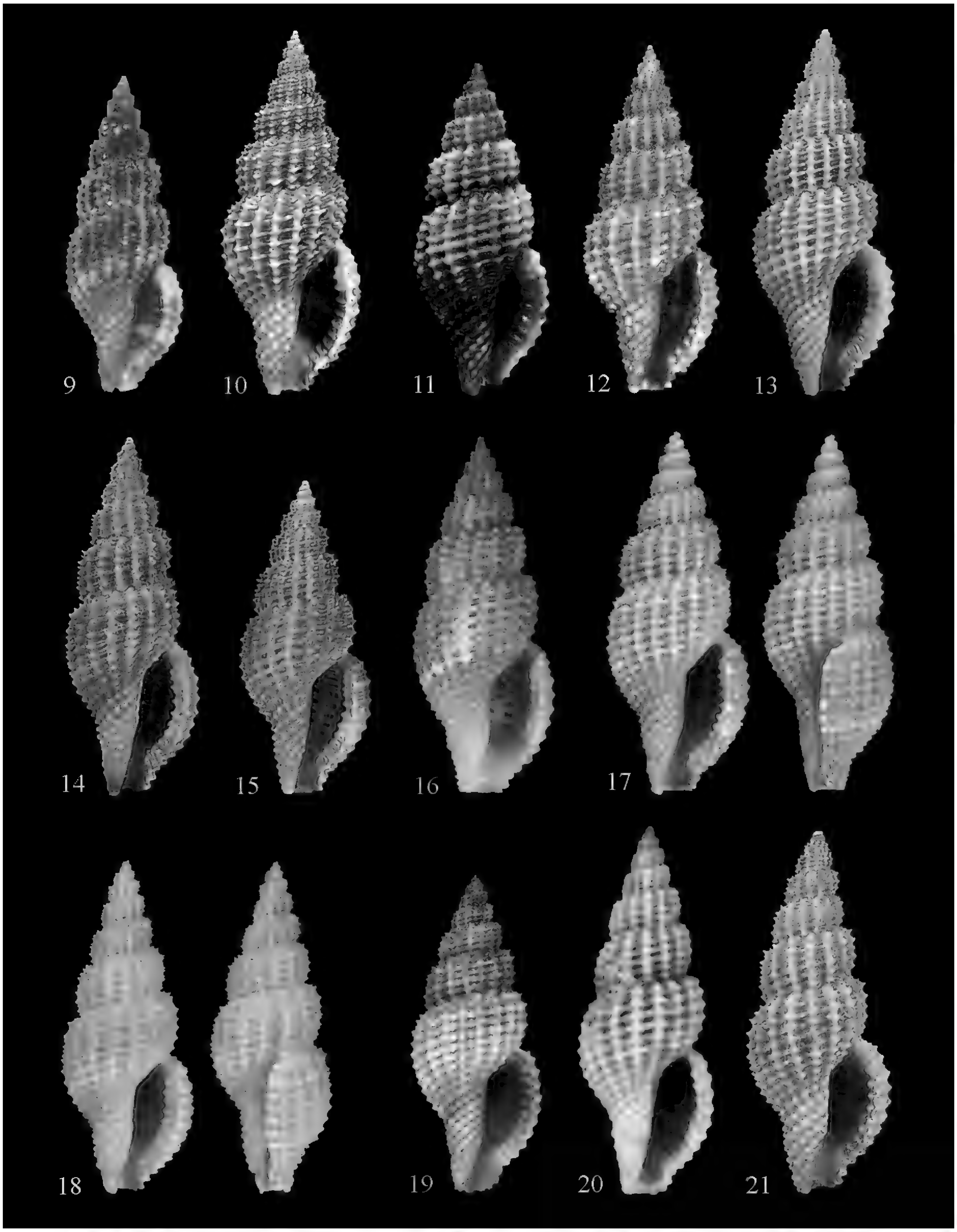
DISTRIBUTION. West and Central Mediterranean.

COMPARATIVE NOTES. Specimens of light-colored *R. atropurpurea* (Locard et Caziot, 1900) (see Pusateri et al., 2017: 174 Fig. 8A) may be confused with *R. corbis* with light suture cordlet (see Fig. 6), but *R. atropurpurea* is distinguished by a less acute and scalar profile, to be more robust, and to the lower number of nodulose cords on the siphonal fasciole (Fig. 23).

Raphitoma corbis can be confused with specimens of light color of *R. laviae* (Philippi, 1846), but it is distinguished by its larger size, by the more acute and scalar profile and by its elongated tubercles (Fig. 24).

It also differs from *R. lineolata* (Bucquoy, Dautzenberg et Dollfuss, 1883) for the more acute profile, lower h/w ratio (2.47 vs 2.67), the lower transparency inside the mouth and the almost total lack of whitish blotches (Fig. 25).

Moreover, *R. densa* (Monterosato, 1884) differs due to the constant presence of ash blotches missing in *R. corbis* (Fig. 26).



Figures 9–21. Shells of *Raphitoma corbis* (Potiez, 1838). Fig. 9: Civitavecchia (Italy), h: 7.9 mm (with 15 axial ribs); Fig. 10: Boozcada Is. (Turkey), h: 11.8 mm; Fig. 11: Bay of Carini (Italy), h: 8.7 mm; Fig. 12: Isola delle Femmine (Italy), h: 9.3 mm; Fig. 13: Isola d'Elba (Italy), h: 11.7; Fig. 14: Secca Murelle -50 m, Montalto di Castro (Italy), h: 10 mm; Fig. 15: Tuscan Archipelago (Italy), h: 6.5 mm; Fig. 16: Gulf of Termini Imerese (Italy), h: 10.3 mm; Fig. 17: Isola delle Femmine (Italy), h: 10.5; Fig. 18: Gulf of Termini Imerese, h: 8.7 mm; Fig. 19: Tuscan Archipelago, h: 8 mm; Fig. 20: Palermo (MCZR-M-16806), h: 12.2 mm; Fig. 21: Capo Linaro, h: 11.5.

REMARKS. The opinions of various authors on the interpretation of this species are very discordant. Especially since the types were lost during the bombing of 11 August 1944 along with all the naturalistic collections preserved at the Musée de Douai.

Moreover, the collection Michaud (still alive) was in part donated to the Musée of Lyon (now Musée des Confluences), in part passed to the city of Brive by Michaud's son Elysée, and in part was bought by Locard (Locard, 1891: 7). Only the Lyon material remains identifiable (Boyer & Audibert, 2007), but there are no trace of *P. corbis* (Audibert *pers. com.*), the part in Brive having been lost, and the part in Locard's collection having lost the original labels.

The original description of Potiez & Michaud (1838) is suitable for at least 4 or 5 different species of *Raphitoma*.

Monterosato (1872: 51) considers it a variety of *R. purpurea*, but, subsequently (Monterosato, 1878: 106) begins to doubt that it may be a variety of *purpurea* (?) and advances the hypothesis that it may instead be *R. laviae* Philippi, 1844.

Still Monterosato (1880: 229) confirms this synonymy, but seems somewhat hesitant since it does not assign priority to *corbis* Potiez & Michaud, 1838 on *laviae* Philippi, 1844.

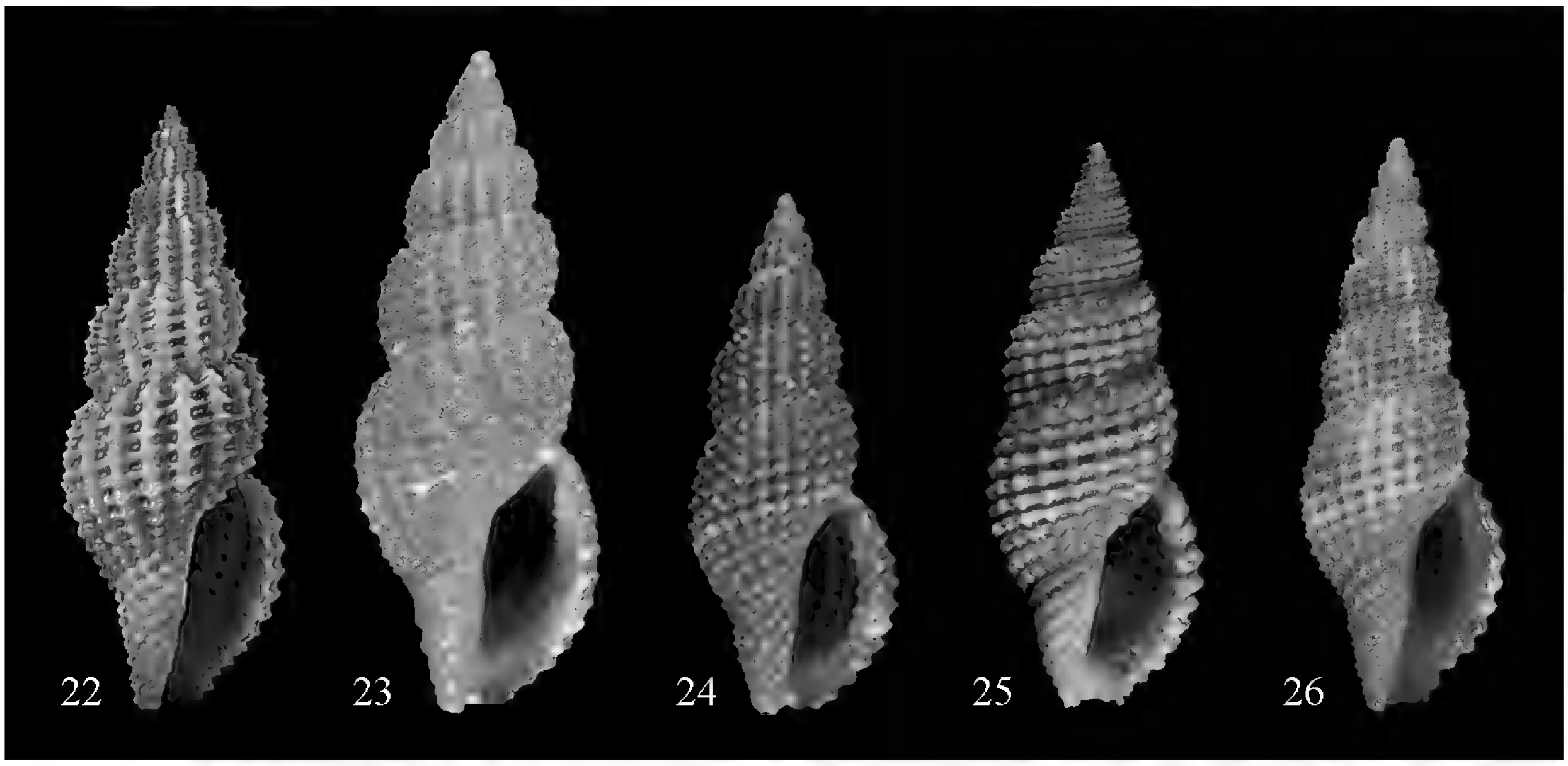
Petit (1869: 154) consider *R. corbis* a young form of *Defrancia purpurea*.

Monterosato (1881) refers to the quotation from Dautzenberg (1882) and assigns the species to the genus *Homotoma* Bellardi, 1875, pointing out that *R. purpurea* "*manca al Mediterraneo* [is missing from the Mediterranean]".

After this date, Monterosato no longer report the *corbis* nor the sustained synonymy with *laviae*. It is possible that he was misled by the original figures of Potiez (1838) and Philippi (1844) that somehow seem quite similar and the size of the two species (4–5 mm given by Potiez and 5.5 mm given by Philippi).

B.D.D. (1882: 91) consider *R. corbis* synonymous with *R. laviae* (in turn considered to be the form of *R. purpurea*) erroneously referring to *R. oblonga* (Jeffreys, 1867). About *R. oblonga* (Jeffreys, 1867) see Giannuzzi-Savelli et al. (2018: 15).

Locard (1891a: 6) reports having had in his hands the original type kept at the Galerie de Douai and states that it is precisely identical to the specimen depicted by B.D.D. (1882, figs. 14, 15). He provides, for the species, a height range between 12 and 14 mm which is very different from that provided by Potiez (1838) in the original description (4–5 mm). Conversely, in the caption of the plate 35 n. 1 published in the volume of the Atlas



Figures 22–26. Fig. 22: *Raphitoma corbis*, Neotype, Palermo, Italy (MCZR-M-16806), h: 11.6 mm; Fig. 23: *R. atropurpurea* (Locard et Caziot, 1900), Napoli (Italy), h: 14.6 mm; Fig. 24: *R. laviae* (Philippi, 1846), Genova (Italy), h: 9 mm; Fig. 25: *R. lineolata* (B.D.D., 1882), St. Raphael (France), h: 9.2 mm; Fig. 26: *R. densa* (Monterosato, 1884), Palermo, h: 10.5 mm.

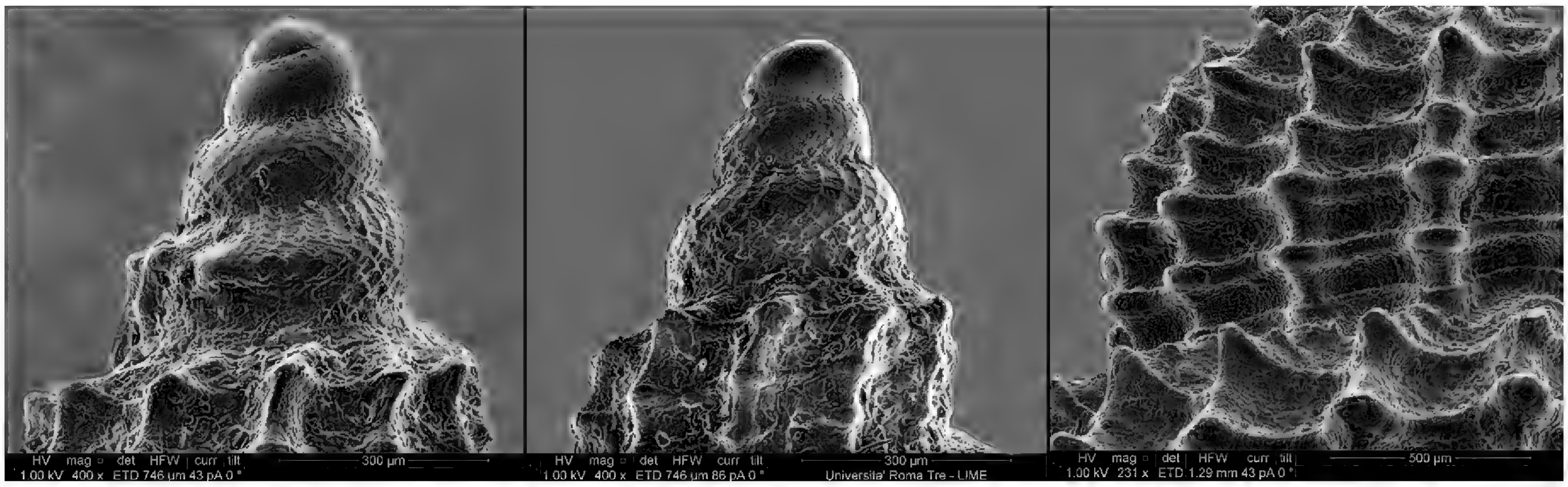


Figure 27. *Raphitoma corbis*. Protoconch and detail of first teoloconch whorl of a specimen from Gulf of Palermo (Italy).

(Potiez, 1844), this author indicates that the illustration is "*grandeur naturelle* [life-size]", or about 12 mm. It is obvious that the measures he gave in the original description (Potiez, 1838) are completely wrong, perhaps due to a printing error.

Locard (1891b: 132) specifies that the specimen examined by him is incomplete but absolutely referable to the *Clathurella contigua* Monterosato, 1884, referring to fig. 15 of B.D.D. (1882) and assumed by Monterosato (1884), for indication, among the types of its *R. contigua*. For a complete treatment of the problem, see Pusateri & Giannuzzi-Savelli (2012), which gave a final arrangemet to *R. contigua*. They fix a lectotype chosen from the original material of the author and illustrating the same sample used by B.D.D. (1882) for their figure 15 (Pusateri & Giannuzzi-Savelli, 2012) which is found to be a typical *R. atropurpurea* of about 12 mm.

Locard's (1891b) assumption is rather strange that, subsequently, in describing with Caziot (Locard & Caziot, 1889 the *R. atropurpurea* makes no reference to the figure 15 of B.D.D (1882). This suggests that Locard (1891b) trusted the rather confusing photograph and did not check the original material used by Dautzenberg for "Les mollusques du Roussillon" (B.D.D., 1882). This material between 1975 and 1980 has now merged into the MNHN collections (V. Heros *pers. comm.*).

On the basis of these statements by Locard (1891b), we checked in his collection at MNHN all the material relating to *Clathurella corbiformis* (Locard had the habit to adjective the nouns and then renaming the species thus creating a plethora of invalid emendationes). We have thus found 7 lots from Saint-Raphaël, Toulon, Paulilles, Marseille, Roussillon, Saint Tropez, and Porto Pollo. To our surprise, this material, in a poor state of preservation, turns out to be a mélange of different species: *R. densa*, *R. atropurpurea*, *R. philberti* (Michaud, 1829), *R. spadiana* Pusateri et Giannuzzi-Savelli, 2012, and the only *R. corbis* present in this material (Roussillon) is labeled as "*atropurpurea*".

This is a further proof of the fickleness of Locard's identifications

In conclusion, for the objective difficulties of determination (see COMPARATIVE NOTES) and a complex nomenclatural history, we consider it appropriate, even for the purpose of maintaining the nomenclatural stability, to designate a neotype.

Consequently (art. 75.3 ICZN, 1985), we have chosen a sample of the Monterosato MCZR-M-16806 collection marked with two labels: "*Ph. atropurpurea*" and "*Palermo, 1886*".

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Comparative study on the Anuran Communities (Amphibia Anura) in Agusan Marsh Wildlife Sanctuary, Philippines

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ABSTRACT The Agusan Marsh Wildlife Sanctuary harbors numerous species of Anurans (Amphibia Anura) that have highly threatened habitats. The species of anurans were observed in different vegetation types such as Terminalia forest, sago palms, and rice fields in the Agusan Marsh Wildlife Sanctuary, Bunawan, Agusan del Sur on May and October 2008. Result showed abundant, diverse, endemic, and threatened anuran species. Nine species of frogs with 148 individuals were documented. The sago forest had the highest anuran population with 76 invividuals (3 species) followed by 41 (5 species) in the Terminalia forest and 31 (3 species) in the agricultural areas adjacent to sago stands. Of these, 66.7% are Philippine endemics. However, the remaining 33.3% are threatened by natural habitat conversion. Naturally grown sago stands are ultimately a habitat for several anurans found only in the Philippine archipelago. *O. laevis* and *L. leytensis* are identified as sago forest indicators. Indeed, their absence or decline in population over time may have detrimental impact on the survival of the sago stands in the Agusan wetlands. The anuran species are highly habitat specific. Indeed, sago stands harbor endemic and unique anuran species that need to be conserved and protected.

KEY WORDS Agusan marsh; amphibians; biodiversity; conservation; protection.

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INTRODUCTION

The Philippines has diverse flora and fauna but are now highly threatened by human activities. To date, the country has a high percentage of amphibian endemism (more than 50%) compared to other groups of wildlife such as mammals, birds, and reptiles. Currently, an estimate of 105 species are present in the Philippines, which may increase to 160 species considering future conservation studies on evolutionary diversification using morphological characteristics, genetic data, and mating calls (Brown et al., 2008). Therefore, there is no doubt about future discoveries of new species in the Philippines in addition to the present count (Taylor, 1923, 1925 as cited by Brown & Gonzalez, 2007).

One of the protected areas in the country, the Agusan Marsh Wildlife Sanctuary, harbors unique species of wildlife. This wetland is characterized by extensive floodplains and shallow lakes that shrink and partially dry up from April to October and flood from November to late March (RAMSAR, 2003). It is important not only because of its many ecolog-

ical functions, from providing habitats to wildlife, water cycling and carbon sequestration, to regulating local climate, but also of its economic importance to local communities. Not only it holds undiscovered and potentially important species, but it is also the temporary home of migratory birds from temperate regions.

The marsh has different habitat types, such as the Philippines' largest Terminalia forest, dominated by *T. copelandii* (Frazier, 1999). This type of forest is an important source of high value timber and other non-wood forest products. Another vegetation type is sago palms, which are interspersed and scattered through the forest. *Metroxylon sagu* Rottb., known as sago, serves as a staple food for indigenous people in the area during the wet season or when there arefloods as substitute for rice (Flach, 1997). Ecologically, swamps and wetlands, home to the sago palms, are among the richest biomes. Sago palms grow in Mindanao and Visayas dry portions, unlike in the Agusan wetlands. Sago palms grow individually or in dense clumps (Mason, 2000 as cited by Palafox, 2006) and are distributed along Southeast Asia, South Pacific, and South America. However, most of the Terminalia forest and the sago palm areas are converted for agricultural production, especially to rice fields, thus threatening the natural habitats of the fauna. As biological indicators of the health of the environment, anurans can be a gauge for disturbed and undisturbed sites since they have a wide range of habitats. Some species are highly sensitive to environmental changes, while others are more tolerant to disturbances.

In addition, anurans have a broader range of habitat preferences. By comparing upland studies to other parts of Mindanao (Mt. Hamiguitan Wildlife Sanctuary, Davao Oriental), and other studies in Lake Sebu, South Cotabato, there is still an observable high endemism and a certain diversity of amphibians (Ates et al., 2008; Rovillos et al., 2008). They are highly specific and diversified (D=3.66) in aquatic habitats with wide distribution in lowland vegetation. More than 70% of the endemism occurred in Mt. Hamiguitan. Few of these endemic species were threatened. Around 16 species were also counted in Lake Sebu with four families. Unsustainable agricultural practices and other anthropological disturbances harm water bodies and low vegetation in Lake Sebu. Another study in the mountainous areas in Mt. Sambilikan found and recorded 21 species belonging to four families, of which 12 (57%) are endemics, while 8 were threatened (Fabricante & Nuñeza, 2008). Habitat loss, wildlife hunting, and forest conversion continue to be local threats to their survival.

Thus, this study aimed to determine the recent species composition, diversity, and richness, as well as the endemisms and current threats for anurans, with reference to three types of vegetation such as the Terminalia forest, the sago stands, and the agricultural area in marginal habitats of the Agusan wetlands. The purpose was primarily to examine the role of the sago palms as a key habitat for anuran species and observe the pattern of anuran communities along with habitat modifications.

MATERIAL AND METHODS

Habitat Characterization

The fieldwork was conducted in three selected types of vegetation and habitat utilized by amphibians: the Terminalia forest, the sago stands, and the agricultural area of the Agusan Marsh Wildlife Sanctuary located at $8^{0}19'0''$N - $125^{0}52'0''$E (Figs. 1-4). A total of eight sampling sites composed of five sites in the sago forest with the adjacent agricultural areas and three sites of the Terminalia forest in Kaliloan, Bunawan, and Agusan del Sur were carried out on May and October 2008.

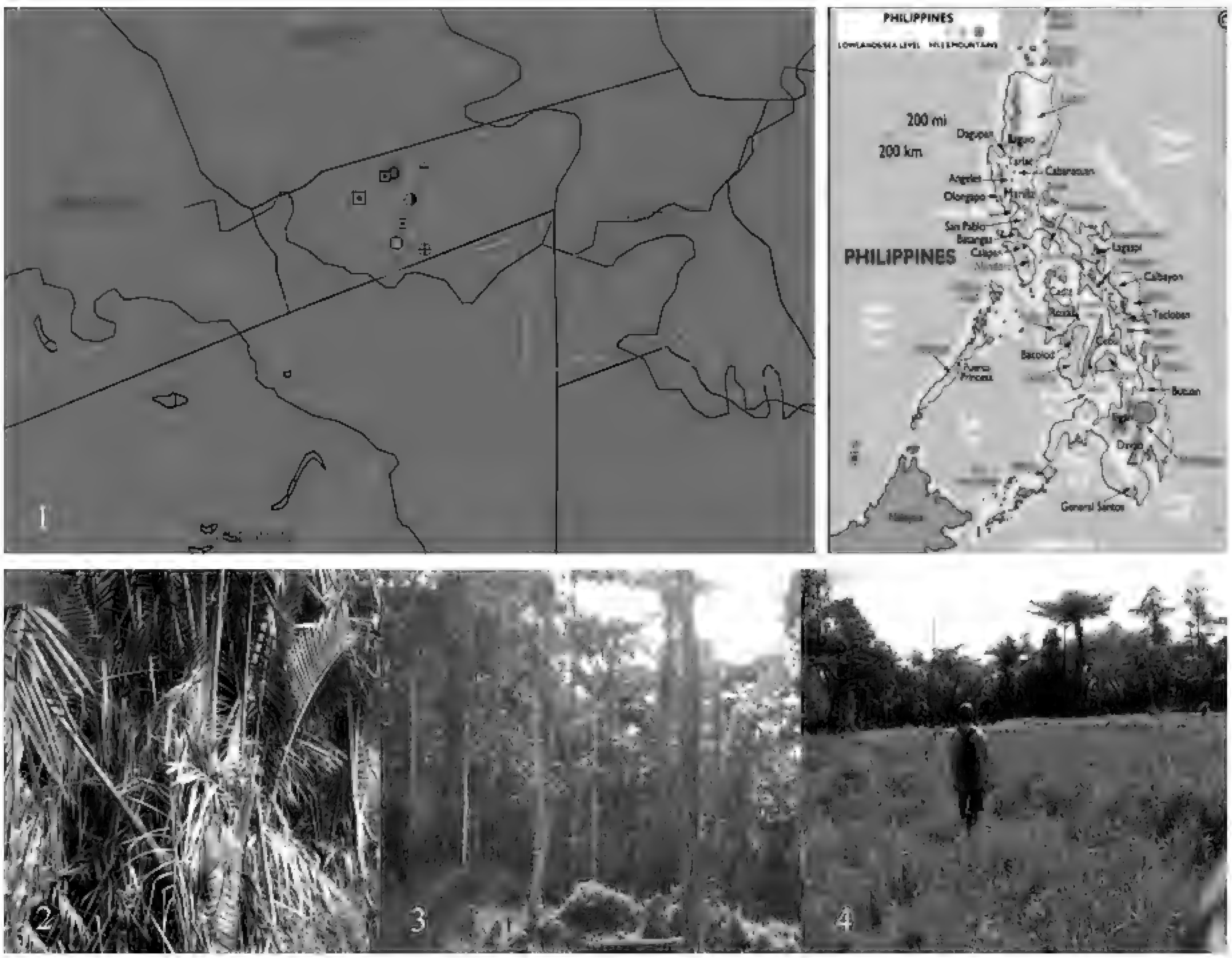
These identified areas have different vegetation. Some were old-growth forest of Terminalia, while other areas have sago stands and the other portion of the site is filled with rice fields. They appeared as patches, ranging from 0.5 ha. to more than 50 ha. and serving as buffer zones of the Agusan marsh. The first, second, and fifth sites were smaller patches, while the third and fourth sites were larger patches. However, the sites were disturbed due to slash and burn practices encroaching and converting the Terminalia and the sago forests into rice fields. The vegetation associated to the sago stands are dominated by large trees, vines, epiphytes, and thick humus cover. The sixth site is connected to a large timberland, while the seventh site is a large patch of the Terminalia forest and

other woody trees. Wildlife hunting, clearings, and slash and burn practices are prevalent threats in the eight site of the Terminalia forest. This area is adjacent to the sixth site at the border with the Agusan marsh.

Anuran Survey and Its Efficiency

A 100 meters transect line was established from the edge to the interior of each habitat type, such as the Terminalia forest, sago stands, and rice fields. Direct counts of amphibians through visual encounter technique and opportunistic sampling along the line transects were used to sample amphibians. Sampling was done from 1800 h to 2200 h per night, from May 10 to 20 and from September 24 to October 1, 2008. Transect studies were conducted during periods with the greatest animal activity, especially during the night. The first major fieldwork began in the sago forest, followed by the agricultural area and the Terminalia forest. In these sites, flooded forest floor, palm foliage, and other low-lying vegetation were extensively searched for possible amphibian inhabitants.

Frogs were collected using bare hands in each microhabitat and placed in plastic containers. Morphometrics such as snout to vent length (SVL), head length (HdL), hind limb length (HL), forelimb length (FL), and tibia length (TbL) were measured using a vernier caliper. Distinguishing morphological characteristics were also noted and compared to the descriptive data of the Philippine frogs by Alcala (1982). Man-hours were calculated by multiplying the number of collectors and the number of hours spent searching for frogs in



Figures 1-4. Map of the Philippines and location of the eight sampling points in Agusan marsh (Fig. 1) characterized by three vegetation types such as: Fig. 2: sago stands in water-logged areas. Fig. 3: Terminalia forest. Fig. 4: ricefield, Bunawan, Agusan del Sur, Mindanao Island.

each site. Initial records showed six anuran species in the sago forest and its neighboring habitats, documented in 10 man-hours. This number increased to seven species in 17.5 man-hours and climbed up to nine species after 27.5 man-hours. Thereafter, the number of species remained stable up to the last sampling efforts provided. There was definitely a sufficient sampling effort provided in varied vegetative cover in the Agusan marsh.

The number of amphibians for every man-hour in each habitat is used to estimate occurrence and relative abundance of the species. Philippine endemic species and threatened ones were also counted and analyzed. Current conservation status based on the International Union for the Conservation of Nature (IUCN, 2017) was determined for each species. Geographic distribution was digitally mapped for future monitoring purposes of the sago areas and its associated vegetation as their habitats. Simpson's and Shannon-Weaver's diversity indices, richness, evenness and Jaccard's similarity coefficient were calculated to assess the status of the Agusan marsh.

Family	Scientific Name	Common Name	Local Name	Conservation Status (IUCN 2008) and Geographic Distribution	Micro-habitat	Sago Forest	*Terminalia* Forest	Agricultural Area	Total
Ranidae	*Limnonectes leytensis*	Small Disked Frog	*Baki*	Least Concern and Philippine Endemic (Decreasing)	Water	34	3	-	37
Ranidae	*Occidozyga laevis*	Yellow Bellied Puddle Frog	*Umpo*	Least Concern and Philippine Endemic (Stable)	Water	41	6	-	47
Ranidae	*Fejervarya cancrivora*	Asian Brackish Frog	*Baki*	Least Concern and Southeast Asia (Stable)	Soil	-	-	12	12
Ranidae	*Fejervarya vittigera*	Luzon Wart Frog	*Baki*	Least Concern and Philippine Endemic (Stable)	Soil	-	-	12	12
Rhacophoridae	*Polypedates leucomystax*	Four- lined Tree Frog	*Baki*	Least Concern and Southeast Asia (Stable)	Foliage	-	-	7	7
Rhacophoridae	*Philautus acutirostris*	Philippine Bubble Nest Frog	*Baki*	Vulnerable and Philippine Endemic (Decreasing)	Foliage	-	12	-	12
Microhylidae	*Oreophryne anulata*	Chaperina visaya	*Baki*	Vulnerable and Philippine Endemic (Decreasing)	Foliage	-	17	-	17
Bufonidae	*Rhinella marina*	Giant Marine Toad	*Baki*	Least Concern and Southeast Asia (Increasing)	Soil	1	-	-	1
Bufonidae	*Pelophryne lighti*	Light's Toadlet	*Baki*	Vulnerable and Philippine Endemic (Decreasing)	Foliage	-	3	-	3
Total number of species:						3	5	3	9
Total number of individuals:						76	41	31	148
Total number of families:						2	4	2	4
Total number of Philippine endemics:						2 (66.7%)	5 (100%)	1 (33.3%)	6 (66.7%)
Total number of threatened species:						0	3 (60%)	0	3 (33.3%)

Table 1. Anuran species inhabiting Agusan marsh, Bunawan, Agusan del Sur, Mindanao, Philippines.

Scientific Name	Population	Snout to vent length (SV) (mm)	Head length (HdL) (mm)	Hindlimb length (HL) (mm)	Forelimb length (FL) (mm)	Tibia length (TbL) (mm)	Most Distinguishing Characters
Limnonectes leytensis	37	34.4±10.1	13.1±12.7	50.9±14.4	16.2±5.6	17.3±8.1	Inverted V mark on dorsal side
Occidozyga laevis	47	33.5±6.2	9.8±3.5	43.4±7.6	12.4±3.9	12.7±3.3	Short legs; with or without middorsal line
Fejervarya cancrivora	12	55.3±10	18.2±4.2	85.9±21.6	23.8±5.8	29.1±7.1	Smooth dorsal side; stout bodied
Fejervarya vittigera	12	56.1±15.5	18.8±5.9	78.9±28.5	25.3±7.6	27.9±8.7	Rough dorsal markings; big body
Polypedates leucomystax	7	47.1±3.7	14.6±2.8	70.4±7.8	19.1±6.9	22.6±4.7	Long legs; large slender body
Philautus acutirostris	12	19.8±2.0	8.6±1.9	32.5±3.1	9.7±2.2	11.6±2.0	Short, long legs; arboreal
Oreophryne anulata	17	12.5±3.9	4.2±3	19.4±4.3	5.7±2.9	5.8±3.2	Short, slender bodies; arboreal
Rhinella marina	1	100.0	28.0	95.0	60.0	37.0	Warty frog; exotic; poisonous
Pelophryne lighti	3	9.3±1.5	1.0	15.3±3.1	1.9±1.7	1.2±0.8	Short, slender body; light middorsal line

Table 2. Morphometric data and phenotypic characters used to identify anuran species in the sago forest and its environs, Agusan marsh, Kaliloan, Bunawan, Agusan del Sur.

Biodiversity Measurements	Sago Forest	*Terminalia* Forest	Agricultural Area	Agusan Mars h
Species Richness (d)	3.8	3.2	3.0	1.7
Simpson's Diversity Index (D_s)	0.5±0.11	0.7±0.06	0.6±0.06	0.8±0.035
Shannon-Weaver's Diversity Index (H')	1.1±0.22	2.0±0.23	1.5±0.026	2.60
Evenness of Shannon-Weaver's Index (J')	0.7	0.9	3.2	0.9
Evenness of Simpson's Index (E_s)	0.8	0. 9	1.0	0.8
Jaccard's Similarity Coefficient (CCj)	Sago palms and *Terminalia* (0.33)	*Terminalia* and Agricultural area (0)	Sago palms and Agricultural area (0)	

Table 2. Biodiversity measurements of anuran communities in Agusan wetlands, Bunawan, Agusan del Sur, Mindanao, Philippines.

RESULTS AND DISCUSSIONS

Species Composition and Abundance of Anurans in the Agusan Marsh

The number of captured amphibian species in the sago forest as well as in the adjacent Terminalia forest and the agricultural area in the marshland of Agusan reached 148 individuals with nine species assigned to four families: Ranidae, Rhacophoridae, Microhylidae, and Bufonidae (Table 1). Among them, there are the *Limnonectes leytensis* (Boettger, 1893), *Occidozyga laevis* (Günther, 1858), *Polypedates leucomystax* (Gravenhorst, 1829), *Philautus acutirostris* (Peters, 1867), *Fejervarya cancrivora* (Gravenhorst, 1829), *Oreophryne anulata* (Stejneger, 1908), *Rhinella marina* (Linnaeus, 1758), *Pelophryne lighti* (Taylor, 1920), and *Fejervarya vittigera* (Wiegmann, 1835). Previously, only three families of anurans such as Ranidae, Rhacophoridae, and Microhylidae which included eight species such as *Fejervarya cancrivora*, *Pulchrana grandocula* (Taylor, 1920), *Rana parva* Taylor, 1920, *Occidozyga laevis*, *Platymantis dorsalis* (Duméril, 1853), *Polypedates leucomystax*, *Philautus acutirostris*, and *Kaloula conjuncta* (Peters, 1863) were recorded (Cabelin, 2007). Other species found in the Agusan marsh were *Pulchrana grandocula*, *Polypedates leucomystax*, *Kaloula conjuncta*, and *Occidozyga laevis* (Palafox, 2006).

The most abundant species of amphibians is *Occidozyga laevis* (47), followed by *Limnonectes leytensis* (37), *Oreophryne anulata* (17), *Fejervarya cancrivora*, *Philautus acutirostris,* and *Fejervarya vittigera* (12), *Polypedates leucomystax* (7), and *Rhinella marina* (1) (Figs. 5–10). The highest number of anurans is found in the sago stands (76) with three species such as *Occidozyga laevis* (41), *Limnonectes leytensis* (34), and *Rhinella marina* (1). This is followed by the Terminalia forest (41) with a slightly higher number of species (5) such as *Pelophryne lighti* (3), *Oreophryne anulata* (12), *Philautus acutirostris* (17), *Occidozyga laevis* (6), and *Limnonectes leytensis* (3). The agricultural area is preferred by three species of anurans, namely: *Fejervarya vittigera* (12), *F. cancrivora* (12), and *Polypedates leucomystax* (7), with a total of 31 individuals (Fig. 11).

The nine species of anurans in the sago forest and its associated vegetation varies in morphological measurements (Table 2). Based on the measured body lengths, the biggest in size relative to other species are *Rhinella marina* and *Fejervarya vittigera*, followed by *Fejervarya cancrivora*, *Polypedates leucomystax*, *Limnonectes leytensis*, *Occidozyga laevis*, *Philautus acutirostris*, *Oreophryne anulata*, while the smallest is *Pelophryne lighti*. They vary highly in morphological characteristics like the possession of rough or smooth dorsum, short and long legs, poison glands, and dorsal markings. These are all influenced by the type of life of the anurans in freshwater, terrestrial, and arboreal microhabitats.

Microhabitats and Species Diversity of Anurans in the Agusan Marsh

The number of aquatic and arboreal species is generally greater in the Agusan marsh (Fig. 12). In the Terminalia forest, arboreal species were more abundant than aquatic and terrestrial species. Meanwhile, aquatic species were more in sago stands compared to the terrestrial inhabitants. More terrestrial species dwell in the agricultural areas compared to the sago and Terminalia forests. Most *Occidozyga laevis*, *Limnonectes leytensis*, *Fejervarya vittigera*, and *Fejervarya cancrivora* highly preferred the waterlogged habitat of the sago forest and the adjacent agricultural area rather than the Terminalia forest. Soil availability and a stable amount of water support the survival and reproduction of frogs. Tree frogs such as *Philautus acutirostris*, *Pelophryne lighti*, and *Oreophryne anulata* live in the Terminalia forest, reaching up to more than 18 meters high and they are mainly situated in the sago forest. These species reside among the leaves and branches of tall grasses and trees. *Polypedates leucomystax* and *Rhinella marina* instead are considered as biological indicators of habitat disturbance in the marsh. The rise of their population number is an output of the highest disturbance level occurring in the forests.

The species richness of frogs in the Agusan marsh is d=1.68 (Table 3). Amphibian diversity values are Ds=0.801 (J'=0.9) and H'=2.637 (ES=0.83) using Simpson's and Shannon-Weaver's diversity indices, respectively. There is a higher anuran diversity in this study (H'=1.464) compared

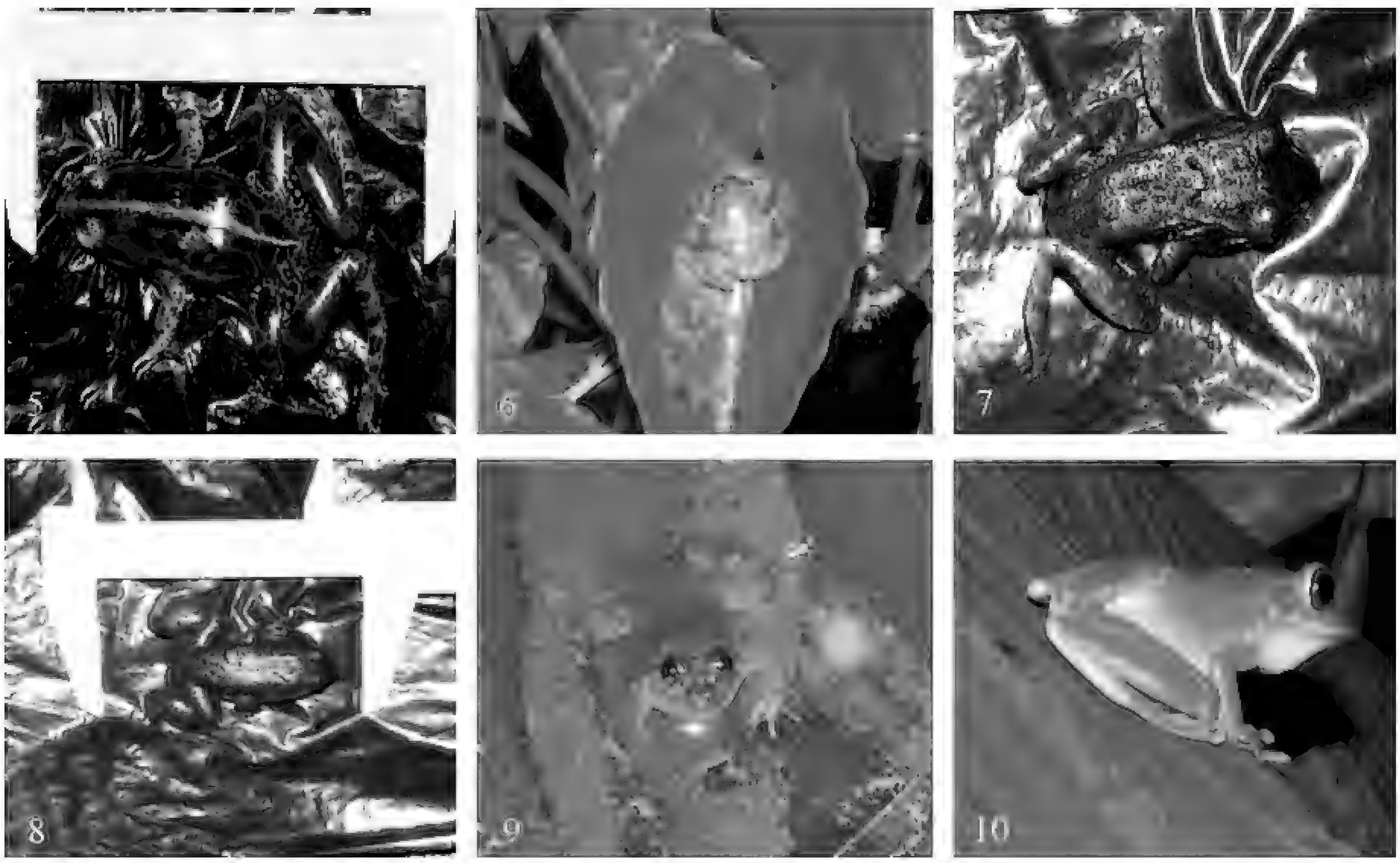
to Cabelin (2007). The sago forest (3.8) had relatively rich amphibian species compared to the Terminalia (3.23) and agricultural area (2.99). The Terminalia forest (Ds=0.71, Es=0.89) adjacent to the sago stands had significantly higher amphibian diversity (Ds) followed by the agricultural area (Ds=0.65, Es=0.97) and the sago forest (Ds=0.51, Es=0.76). Using Shannon-Weaver's diversity index, the Terminalia forest had consistently the greatest diversity of amphibians (H'=2.00, J'=0.86) compared to the agricultural area (H'=1.54, J'=3.24) and the sago forest (H'=1.08, J'=0.68). The sago stands served as an alternative habitat for most amphibian species in the Agusan marsh, since these areas are also almost immersed in water throughout the year, similarly to the Terminalia forest. However, some of the water from the forest flow to the rice fields endangering the habitat of frogs.

The composition of anurans between the sago and the Terminalia forests (CCj=0.33) is highly similar. On the contrary, such composition is much more dissimilar between the Terminalia and the agricultural area and the sago forest and the agricultural field. This finding implicates that the sago stands have a greater role in maintaining the diversity of anurans in the Agusan wetlands as a whole. Anurans are highly dependent to the sago forest and the timberland. They specialized more on the available food resources such as insects (Hymenopterans, Hemipterans and Orthopterans), foliage, seed, amphibian tadpole, and fish (Palafox, 2006).

Endemicity and Conservation Status of Anurans in the Agusan Marsh

In the Agusan wetlands, Philippines endemic frogs are more abundant (66.7%) than non-endemics (Fig. 13). The Terminalia forest has the highest endemism, followed by the sago forest and rice fields.

Endemics are abundant in areas with less disturbed vegetation. Naturally grown sago palms and Terminalia trees in water-logged areas are preferred by anurans. Mindanao endemics are ab-



Figures 5–10. Anuran species found in Agusan marsh, Bunawan, Agusan del Sur, Mindanao. Fig. 5: *Fejervarya cancrivora.* Fig. 6: *Oreophryne anulata.* Fig. 7: *Limnonectes leytensis.* Fig. 8: *Occidozyga laevis.* Fig. 9: *Fejervarya vittigera.* Fig. 10: *Polypedates leucomystax.*

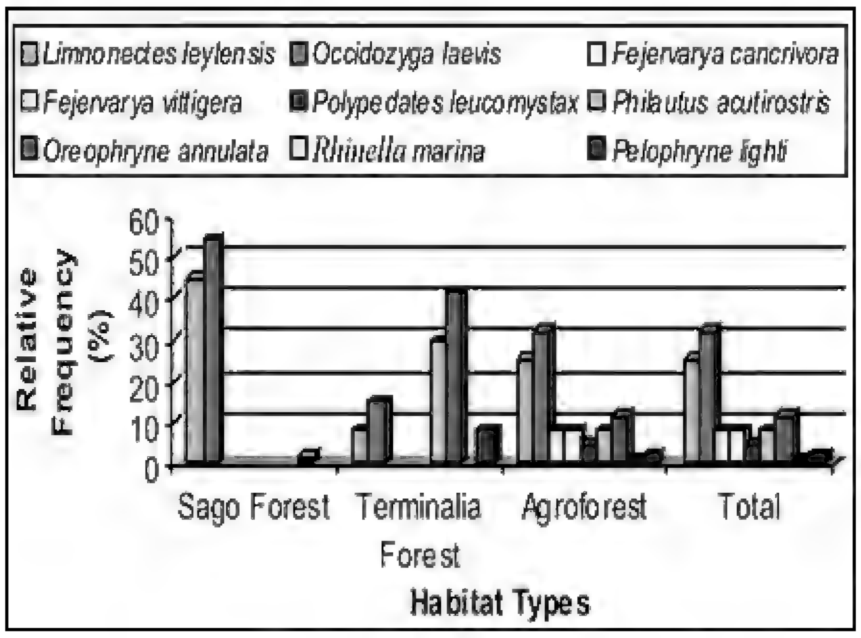


Figure 11. Relative frequency (%) of anurans in three kinds of habitat in Agusan wetlands, Bunawan, Agusan del Sur, Mindanao, Philippines.

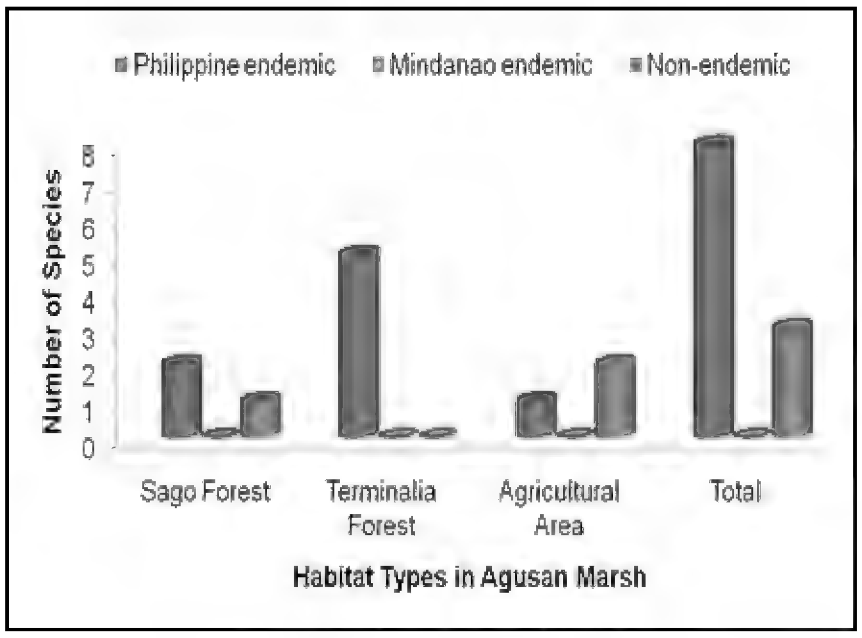


Figure13. Philippine endemics and non-endemics in sago forest, Terminalia forest, and agricultural area, Agusan wetlands, Bunawan, Agusan del Sur, Mindanao, Philippines.

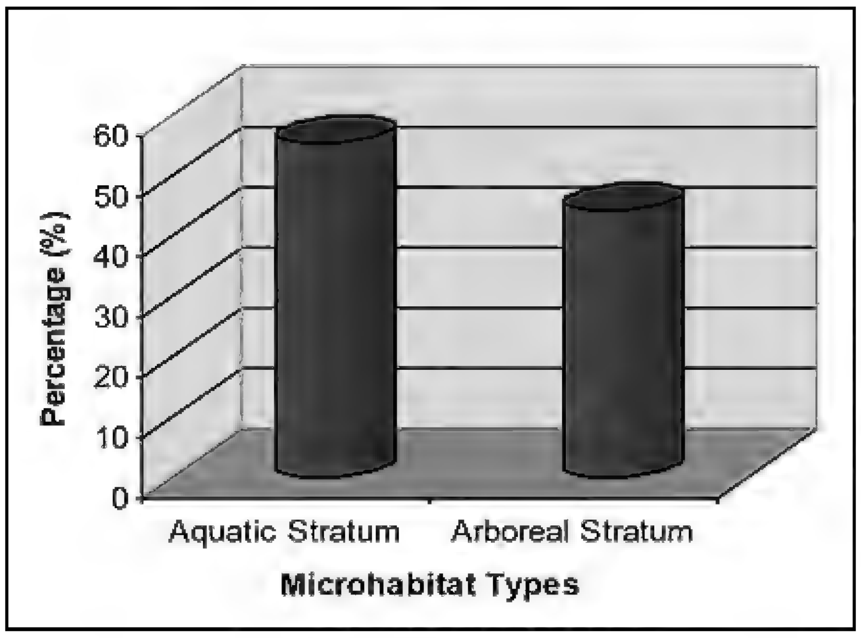


Figure 12. Microhabitat preference (%) of amphibian species documented in sago forest and its associated vegetation in Agusan wetlands, Kaliloan, Bunawan, Agusan del Sur.

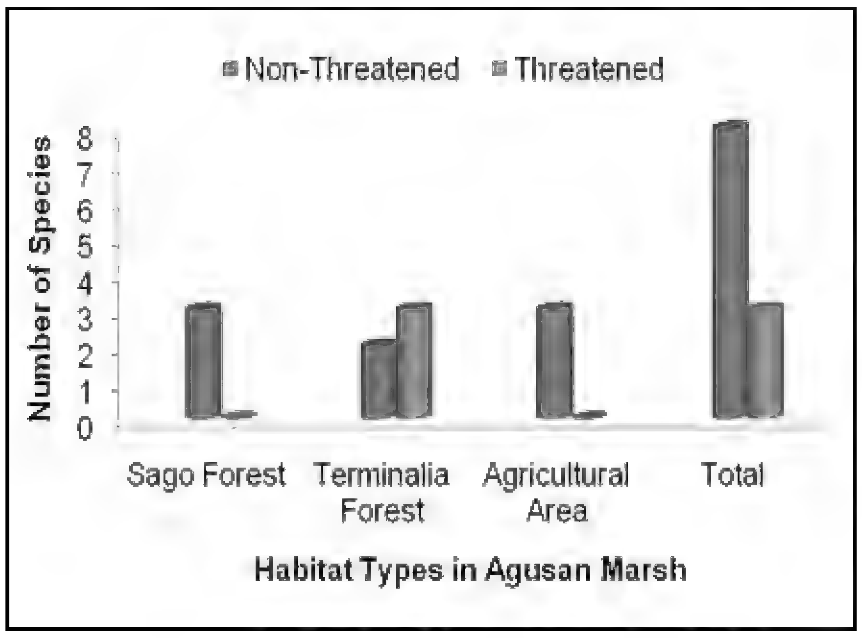


Figure 14. Threatened and non-threatened anurans in sago forest, Terminalia forest, and agricultural area, Agusan wetlands, Bunawan, Agusan del Sur, Mindanao, Philippines.

sent in this wetland. Conversely, non-endemics predominated the cultivated areas like the rice fields. They proliferate and survive in disturbed habitats.

Threatened species accounted for 33.3% since their habitats have been exploited by slash and burn practices and some of them served as subsistence for human consumption (Fig. 14). In the Terminalia forest, rather than sago forest and agricultural areas, threatened species are more abundant than non-threatened ones. This record may be attributed to a bigger habitat fragmentation occurring in the Terminalia forest and the agricultural field than in areas naturally grown with sago. In earlier studies, which began in 2003 (Ibanez & Bastian, 2004), 12 species were found and assigned to five families and 11 genera. Among them, there were three vulnerable species (*Ansonia muelleri*, *Philautus acutirostris,* and *Megophrys stejnegeri*) and a threatened species (*Limnonectes magnus*) documented.

CONCLUSIONS

Indeed, the Agusan Marsh Willdife Sanctuary harbors anurans that are good biological indicators of habitat disturbance. Anurans exhibited high di-

versity, endemisms, and threatened status in the Terminalia and the sago forests. Naturally grown sago stands ultimately serve as a habitat for more endemic anurans. The aquatic and arboreal species are highly habitat specific. Therefore, the sago stands harbor endemic and unique species and utilizing this habitat for reproduction and survival is the key to retaining biodiversity in the Agusan marsh.

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On the presence of *Cyphosoma lawsoniae lawsoniae* (Chevrolat, 1838) (Coleoptera Buprestidae) in Sicily, Italy

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ABSTRACT *Cyphosoma lawsoniae lawsoniae* (Chevrolat, 1838) (Coleoptera Buprestidae) had already been reported in the past for Sicily (Italy). However, its presence on the island is doubted due to the lack of recent records. In the present paper, the occurrence of this species in Sicily is confirmed by one finding in Catania's Plain (Catania province, East Sicily). A short description of the finding locality is given.

KEY WORDS Distribution; Buprestidae; *Cyphosoma*; Sicily.

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INTRODUCTION

The genus *Cyphosoma* Mannerheim, 1837 (Coleoptera Buprestidae) comprises a dozen palaearctic taxa (Kubáň, 2006), of which two occour in Italy: *C. euphraticum euphraticum* (Gory et Laporte, 1839), with Turanic-Eastern Mediterranean geonemy, reported for Apulia, Basilicata, and Calabria, and *C. lawsoniae lawsoniae* (Chevrolat, 1838), a widely diffused in Southern Mediterranean species present only in Sicily and Sardinia (Porta, 1924; Luigioni, 1929; Curletti, 1994; Sparacio, 1997; Curletti et al., 2003; Kubáň, 2006). In particular, *C. lawsoniae lawsoniae* is reported in Sicily only on generic indications, without any specific location. In addition, three specimes conserved in collections of the Entomological Department of the National Museum, Praha-Kunratice, are generically labelled as "Sicilia" (Trojan, 2009).

In this paper, a recent finding of *C. lawsoniae* in Sicily (Catania province) is signaled and the locality of the finding is shortly described.

ABBREVIATIONS. CA: G. Altadonna collection; CS: I. Sparacio collection; ex: specimen; leg.: legit.

Cyphosoma lawsoniae lawsoniae (Chevrolat, 1838)

EXAMINED MATERIAL. Italy, Sicily, Catania province, Belpasso, Simeto river (20 m a.s.l.), Lat. 37°27'00.7"N, Long. 14°55'48.7"E, 6.IX.2015, on *Tamarix* sp., 1 ex, G. Altadonna leg. (CA).

OTHER EXAMINED MATERIAL. *Cyphosoma lawsoniae lawsoniae.* Spain, Cádiz, Chiclana, 2.V.1995, leg. P. Coello, 1 ex (CS); Tunisia, Bizerta, 15.V.1987, leg. I. Sparacio, 1 ex (CS); Italy, Sardinia, Oristano, Sinis, Is. Arutas, 5.VII.1991, leg. M. Romano, 1 ex (CS); Sardinia, Cagliari, Assemini, 17.VI.1993, leg. L. Fancello (CS).

Cyphosoma euphraticum euphraticum. Greece, SE Larissa, Kalamaki, 6.VI.1997, leg. I. Sparacio (CS): Italy, Apulia, Taranto, Marina di Ginosa, 7.VII.2016, 1 ex, leg. G. Cancelliere (CS).

DESCRIPTION. Female. Length from vertex to elytral apex: 14 mm, Convex, bronze, bright. Head with eyes protruding and vertex wide; holes of the antennae without frontal tubercles. Pronotum with deep and dense punctures rounded to the sides and forward. Scutellum visible. Elytra sub-parallel on the sides, restricted to the apex, with bands of deep punctures and two oblique and longitudinal bands of short and dense white pubescence. Legs relatively short, first tarsomere of the rear legs slightly longer than the second one. Prosternal process lodged in a cavity formed in the anterior part from the mesosternum and in the posterior one from the metasternum.

DISTRIBUTION AND BIOLOGY. *Cyphosoma lawsoniae lawsoniae* is a jewel beetle with a South Mediterranean distribution: it is present in Algeria, Egypt, France (Corse), Italy (Sardinia, Sicily), Libya, Morocco, Portugal, Spain, Tunisia (Bellamy, 2008; Kubáň, 2006). Locus typicus is in North East Algeria, near the Mediterranean Sea, close to Annaba municipality, near Bône (Chevrolat, 1838): "*Barbaria. Trouvé par M. Wagner sur les bords de la Seybouse sur le* Lawsonia inermis". Other subspecies of *C. lawsoniae* are recorded coming from East Asia and Central Africa: *C. lawsoniae kalalae* (Obenberger, 1929) for Iraq, Israel and Jordan (Jordan river valley); *C. lawsoniae ennediana* (Descarpentries & Mateu, 1965) for Chad and *C. lawsoniae orientalis* (Bílý, 1983) for Iran (Bellamy, 2008; Kubáň, 2006; see also Trojan, 2009).

Despite various information, the biology of *C. lawsoniae* is little known. In Algeria (Thery, 1928), this species was found in swampy environments on *Schoenus* (Cyperaceae). In Morocco (Cobos, 1955, 1969), it has been reported on *Scirpus maritimus* L. and on other plants with submerged root systems. In Spain, Cobos (1986) reports that the larva is both root-eating and exophyte, while the adults are found on Cyperaceae of the genus *Schoenus* and *Scirpus* or on *Phragmites* (Poaceae). Gobbi (1986), in a work on the hosts plants of Italian buprestids, reports almost all these data and it recalls that the type of this species was collected on *Lawsonia inermis* L. (Lythraceae), a plant native to India, but widely naturalized and cultivated in the Mediterranean area (see also Chevrolat, 1838 and Thery, 1928). Sparacio (1997) indicates this species lives in coastal environment and near river mouths and that its larva is probably rhyzophagous, maybe on Cyperaceae and *Phragmites* sp., on which the adults are often found. According to Curletti et al. (2003), the larva of this species develops on *Scirpus* plants (Cyperaceae). Finally, Trojan (2009) reports the *Bolboschoenus* (*Bolboschoenus*) *maritimus* (L.) Palla (= *Scirpus maritimus*) (Cyperaceae) as the host plant of this species, relying on biological observation conducted in northern Tunisia.

A single Sicilian specimen was found in the early morning (7:00 a.m.) on a low bush of *Tamarix* sp., near the Simeto river. The finding locality is localized in the territory of the Belpasso Municipality (Catania province), in Catania's Plain, over 10 kilometers far from the coast of the Ionian Sea. This riparian environment, surrounded by citrus groves and other crops, is characterized by a warm and very dry climate. Among the plant essences, there are: *Saccharum officinarum* L., *Phragmites australis* (Cav.) Trin. ex Steud, *Glycyrrhiza glabra* L., *Tamarix* sp., and few specimens of *Populus* sp. and *Eucalyptus* sp. Moreover, Cyperaceae and other hygrophilous vegetation are localized in the most wet points.

STATUS AND CONSERVATION. Two Italian species of the genus *Cyphosoma* have very small or restricted populations and they are decreasing due to the degradation or disappearance of the natural environments in which they live because of human activities. According to the IUCN Red List of Threatened Species Categories (2017), they can be classified as Vulnerable (VU).

REMARKS. The morphology of the Sicilian specimen does not differ from what is known for this species (Thery, 1928; Porta, 1929; Cobos, 1986). Particularly, it appears easily distinguishable from *C. euphraticum*, present in Italy, for the presence of two net pubescent longitudinal bands on the elytra. In *C. euphraticum*, the elytra are adorned by irregular, not-contigous pubescent spots.

The occurrence of this species in Sicily was first reported by Ghiliani (1839: Catania, sub *Cyphonota inflata* Dej.), subsequently by Steck (1886, Sicilia, sub *Coeculus gravidus* Lap.) and Ragusa (1893: "... *Questa specie è riportata di Sicilia in tutti i cataloghi*"). *Cyphosoma lawsoniae* is mentioned, generically for Sicily, in the subsequent catalogues on the Italian entomofauna (Porta, 1924; Luigioni, 1929; Curletti, 1994; Gobbi, 1995; Curletti at al., 2003; Kubáň, 2006).

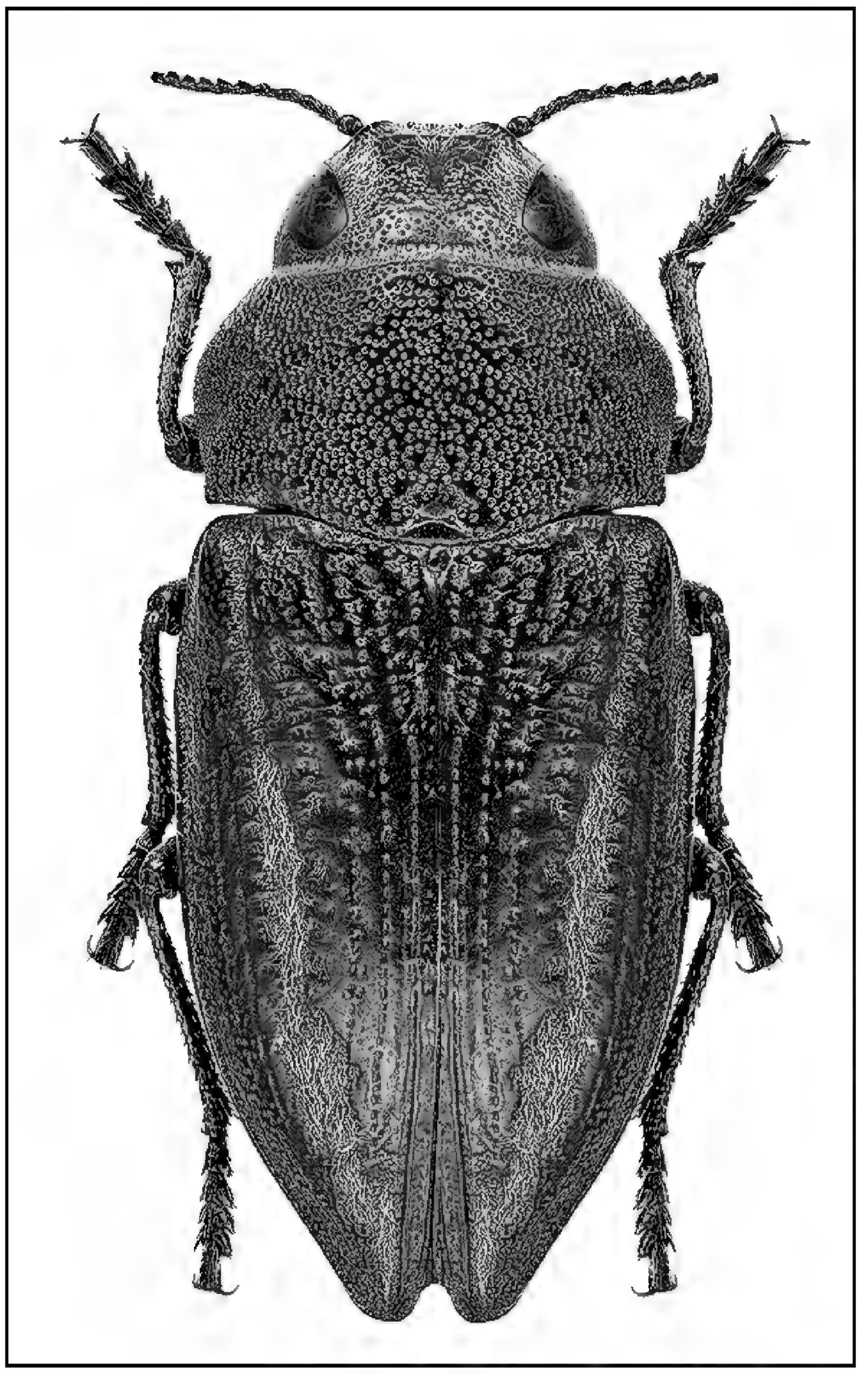

Figure 1. *Cyphosoma lawsoniae lawsoniae* from Sicily.

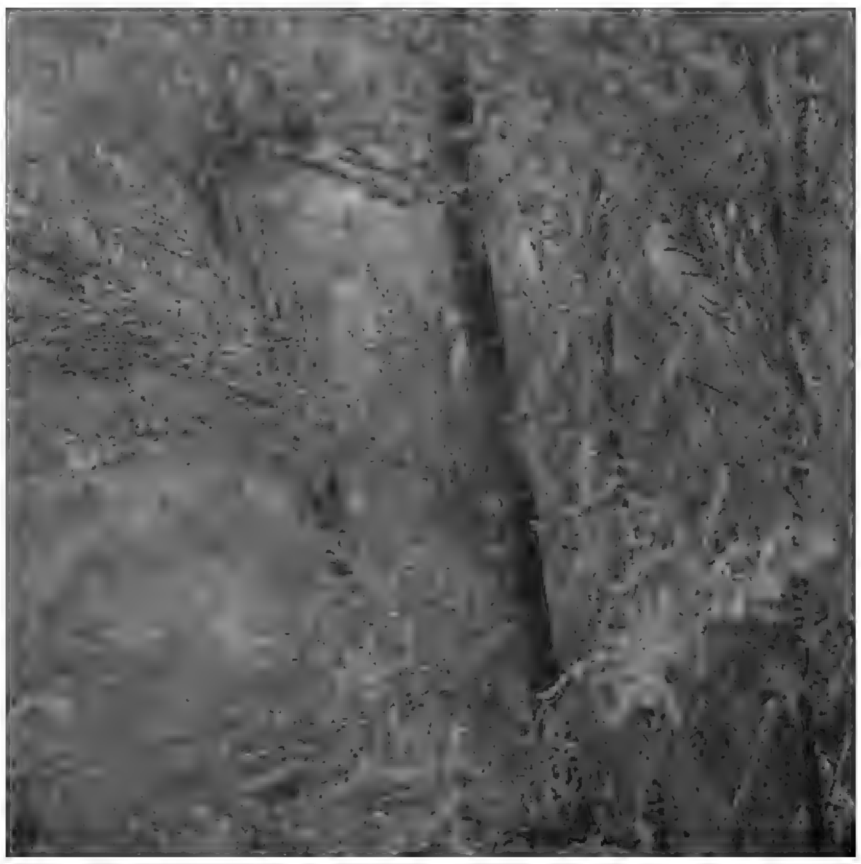

Figure 2. *Tamarix* near the Simeto river (Sicily), place of the *Cyphosoma lawsoniae lawsoniae*.

Therefore, indeed, the first reporting of this species for Sicily by Ghiliani (1839) also quoted the only locality known in bibliography for this species in the island, ignored by the subsequent entomological literature until today, and which overlaps, as geographical area, with the specimen object of this paper.

The presence of *C. lawsoniae* in Sicily is thus confirmed, after almost two hundreds years.

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The bat fauna of the Mpem and Djim National Park, Cameroon (Mammalia Chiroptera)

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ABSTRACT The present study reports on a bat inventory in the Mpem and Djim National Park (Mammalia Chiroptera), in the Centre region of Cameroon. Fourteen sites were surveyed from July 2016 to January 2017. A total of 166 bats were captured. This included 14 species, 11 genera, and five families. All species are globally ranked as "Least Concern" except *Glauconycteris egeria*, a Data Deficient species by the International Union for Conservation of Nature Red List of threatened species. *Micropteropus pusillus* and *Lissonycteris angolensis* were recorded from previous surveys in all the ten regions of the country encompassing five agroecological zones. Out of the fourteen species, ten species are known to occur both in the forest and the savanna, while four are reported only from the forest. This study provides baseline data about Chiropteran fauna of this protected area.

KEY WORDS Cameroon; Chiropteran; Inventory; Mpem and Djim Park.

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INTRODUCTION

The average annual rate of deforestation in Cameroon is among the highest in Central Africa (FAO, 1997). Indeed, Ndoye & Kaimowitz (1998) estimated this deforestation at a rate of 80,000 to 200,000 hectares per year. However, it is clear that tropical forests are the largest reservoir of biodiversity (Fittkan, 1997). Each year, the destruction of millions of hectares of tropical forests involves the disappearance of thousands of plant and animal species, of which most was never indexed (Dubois, 2005). Forests in Cameroon have one of the richest and most diverse fauna in Sub-Saharan Africa (Bikié et al., 2000). They contain several classes of vertebrates, including amphibians (190 species), reptiles (183 species), birds (916 species), and mammals (409 species) (Verbelen, 1999).

Although the Mammal's fauna in Cameroon has been the subject of several studies, bats remain one of the most neglected and poorly studied faunal groups (Bakwo Fils, 2010), despite their major ecological role (Reis & Guillaumet, 1983). Indeed, the valuable ecological services rendered by these animals are ignored by the populations and even by the authorities in charge of managing biodiversity (Bakwo Fils, 2010). Bats, with over 1300 described species, constitute the second most diverse group of mammals after rodents, among the 5000 species of mammals described to date (Bannet-Garcia, 2003). They are unique among mammals as a result of true flight capacity, echolocation abil-

ity, and communal life that could reach several thousands in one assemblage. These poorly known and threatened animals are not included in conservation and wildlife management programs in tropical ecosystems despite their ecological and economic importance (Bannet-Garcia, 2003; Bakwo Fils, 2009a, 2010). This explains the lack of scientific information about bats in Cameroon, which hinders development of effective conservation strategies for these animals.

This preliminary work gives baseline data on the diversity of bats in the Mpem and Djim National Park in the Centre region of Cameroon.

MATERIAL AND METHODS

Study area

The Mpem and Djim National Park is situated in the Centre region of Cameroon (Fig. 1). The climate is a Classic Guinean type with four seasons: a long dry season (from mid-November to mid-March); a short rainy season (mid-March to end of June); a short dry season (from July to August) and a long rainy season (from September to mid-November) (Santoir & Bobda, 1995). Precipitations range between 1800 and 2000 mm^3 per year and the temperatures are found between 22^o and 29 ^{o}C (Santoir & Bobda, 1995). The Mpem and Djim National Park is a vast natural space of 97,480 hectares bounded by the loop which form the Mpem and Djim rivers, two long rivers hosting a rich and diversified aquatic fauna. Recent studies have revealed that the Mpem and Djim Park harbours 76 species of mammals. Among these, rare species (panthers, chimpanzees, hippopotamus, and elephants) are threatened to decline and they even at risk of extinction (MINFOF, 2011). The fact that the park is located in a transition zone between the forest and the savannah gives this protected area a special floristic and faunal character. In the savannah zone there is abundance of *Chromolaena odorata* (L.) R.M. King & H. Rob. (Bokassa Grass) and *Imperata cylindrica* (L.) Raeusch. in the herbaceous layer, while the tree layer is dominated by *Albizzia* sp., *Lophira* sp. and *Ochroma africanus*. In the forest, the following species of trees are dominant: *Piptadeniastrum africanum* (Hook. f.) Brenan, *Milicia excelsa* (Welw.) C.C. Berg, *Pterocarpus soyauxii* Taub., *Nauclea diderrichii* (De Wild. & T. Durand) Merrill, *Alstonia boonei* De Wild., *Mansonia altissima* (A. Chev.) A. Chev., *Garcinia kola* Heckel, *Entandrophragma utile* C. DC., *E. candollei* Harms, *Lovoa trichilioides* Harms.

Bats capture

In the course of our work, we carried out captures in 14 sites within the forest and the savannah ecosystems (Table 1). Capture sites were chosen based on the potential flight trajectories of bats (water, caves, and tree cavities). The captures were made using nylon mist nets of 12x2.60 m and 6x2.60 m with 16 mm mesh and four pockets. These nets were installed for 20 nonconsecutive nights from June 22, 2016 to January 20, 2017 (Table 1). Mist nets were attached to 4 m-long poles and stretched across potential trajectories of bats, such as water bodies, forest openings, cave openings, and tree hollows between 6 pm and 12 pm to maintain uniform sampling efforts across sites. Mist nets were monitored continuously every 15 minutes. Using gloves, the individuals caught in the mist nets were carefully removed to avoid trauma to the animals.

Identification

After capture, each individual caught was weighed using a scale balance (Pesola balance, nearest 0.5 g), measured using a vernier caliper following standard techniques (Lindan et al., 1997), and sexed (Table 3). Presence of tragus (for insectivorous bats), date of capture, and geographic position of capture sites were also recorded. Morphological data from each captured bat is used for identification using the keys of Rosevear (1965), Hayman & Hill (1971), Patterson & Webala (2012), and Happold & Happold (2013). After identification, all individual were released.

Literature review was carried out for each species caught in order to identify the different localities (Table 4) in which they have been previously captured in the country. The African Chiroptera Report (ACR, 2017) was used in order to have some indications on the distribution in Cameroon of the species caught at the park. GPS coordinates of the localities of occurrence retrieved from the database and data from this study enabled us to realize new maps of the distribution of the captured species in Cameroon using the software QGIS 2.4.0 Chugiak.

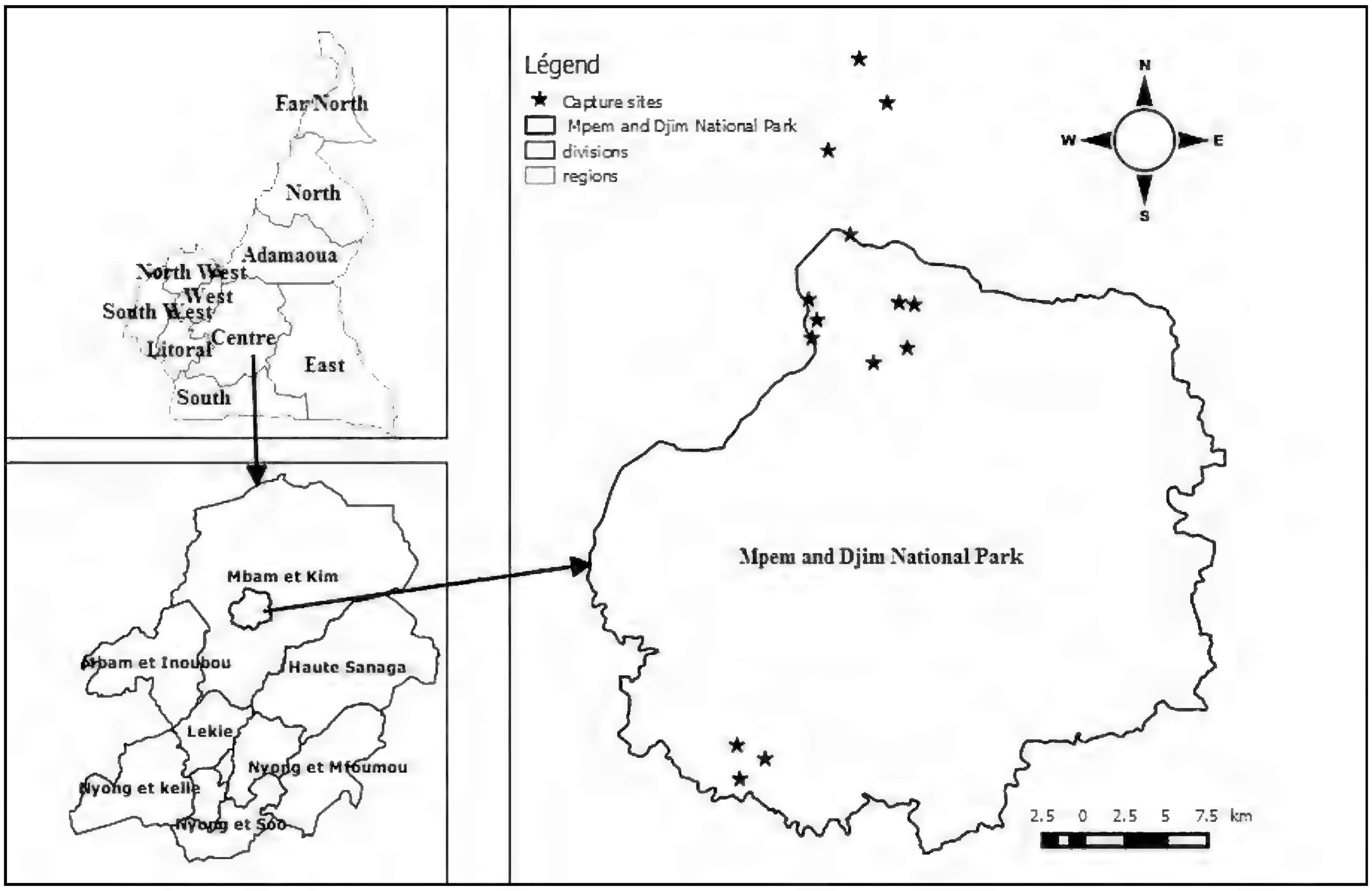


Figure 1. Map of the Mpem and Djim National Park, Cameroon.

SITES	Longitudes	Latitudes	Altitudes	nature of the site	Date	Length and number of net
SITE 1	N 05.03341	E 011.62518	507 m	forest-savannah	22 and 23/07/16	12m(2) and 6m(4)
SITE 2	N 05.04452	E011.63909	542 m	forest	24 and 25/07/16	12m(2) and 6m(4)
SITE 3	N 05.05204	E011.62371	582 m	forest (tree)	26 and 27/07/16	12m(3) and 6m(5)
SITE 4	N05.33230	E011.68691	654 m	savannah	28 and 29/07/16	12m(3) and 6m(5)
SITE 5	N5.26985	E11.71796	630 m	forest	30/07/2016	12m(3) and 6m(5)
SITE 6	N5.26171	E11.69945	657 m	forest	20/11/2016	12m(2) and 6m(4)
SITE 7	N5.27546	E11.66578	607 m	forest	21/11/2016	12m(3) and 6m(5)
SITE 8	N5.28539	E11.66853	631 m	savannah (swamp)	22/11/2016	12m(3) and 6m(5)
SITE 9	N5.29362	E11.72195	674 m	forest	23/11/2016	12m(3) and 6m(5)
SITE 10	N5.29473	E11.71357	632 m	forest	26/11/2016	12m(3) and 6m(5)
SITE 11	N5.29668	E11.66396	639 m	forest	17/01/2017	12m(3) and 6m(5)
SITE 12	N5.37846	E11.67512	617 m	forest (tree)	18/01/2017	12m(3) and 6m(5)
SITE 13	N5.40448	E11.70747	646 m	savannah (cave)	19/01/2017	12m(3) and 6m(5)
SITE 14	N5.42876	E11.69236	792 m	forest (cave)	20/01/2017	12m(1) and 6m(4)

Table 1. Geographical coordinates description of capture sites, date of capture, and number of nets in the Mpem and Djim National Park, Cameroon.

RESULTS

In 20 nights, we captured 166 bats belonging to 14 species, 10 genera, and 5 families. This corresponds to a capture success of 0.69 individuals per night and a capture effort of 239.2 nets per night (Table 2). The family Pteropodidae was the richest in species richness (6 species), followed by Hipposideridae and Vespertilionidae with 3 species each. Rhinolophidae and Nycteridae were monospecific (Table 2).

Species account

Fruit bats

Casinycteris argynnis Thomas, 1910

Only one male individual of this species was captured in the north of the park (forest area) along a river. This species is listed as Least Concern (LC) in the IUCN Red List and its population trend is unknown (Webala et al., 2016). This forest species was previously recorded in Cameroon in Mefo (Peret & Aellen, 1956), Bityé, Mang, Meyo Nkoulou, Mefo (Bergmans, 1990), South Cameroon (Happold & Happold, 2013), Ambam, Meyo, Nkoulou (ACR, 2017) (Fig. 2).

Epomops franqueti Tomes, 1860

Six individuals, including 3 females and 3 males of this species, were captured at sites 2, 10 (secondary forest), and 11 (primary forest). This species is listed as LC in the IUCN Red List and its population trend is unknown (Kityo & Nalikka, 2016). This forest species, captured in the north and south of the park, was previously recorded in Cameroon in Aqua Town, Mungo (Peters, 1876), Kribi (Matschie, 1891), Barombi, Victoria (Matschie, 1895), Itoki (Sjostedt, 1897a & b), Yaounde (Matschie, 1899), Bityé, Bipindi small Batanga (Andersen, 1912), Ndikinimeki, Konn (Aellen, 1952), Ambam, Foulassi, Ngam (Peret & Aellen, 1956), Yaounde (Haiduk et al., 1981), Bamenda, Batanga, Batouri, Bimbia, Bipindi, Bitye, Bota, Buea, Dikume balue, Douala, Ekona, Ekundu, Eseka, Essossong, Foulassi, Garoua, klein, Kuwait, Mumbai, Mbudu, Mengue, Muqiu, Yoko, Idenau, Ikiliwindi, Isobi, Itoki, Konn, Lake Barombi, Mabeta, Mbo, Meanja, Mawutu, Metet, Mukonje, Ndikinimeki, Ngam, Ngaoundere, Tiko (Bergmans, 1988), Kilum-Ijim (Maisel et al., 2001), and Dja Reserve (Bakwo Fils, 2009b) (Fig. 3).

Micropteropus pusillus Peters, 1868

This species is widespread in Cameroon (Fig. 4). Seventeen individuals (10 males and 7 females) were recorded in the north and south of the park. In the north, it was captured beside a river (forest area) and in the swampy savannah. In the south it was caught in the forest-savannah transition zone. This species is listed as LC in the IUCN Red List and its population trend is unknown (Bakwo Fils & Kaleme, 2016a). This species was previously recorded in Cameroon in Yaounde (Matschie, 1895), Tinta (Sanderson, 1940), Ngaoundere (Haiduk et al., 1981; Muller et al., 1981), Banyo (Huterrer & Joger, 1982), Jauro Massali (Huterrer et al., 1992), Bafut, Banyo, Bota, Buea, Boukma, Campo, Djohong, Ekona, Eseka, Koutaba, Kribi, Galim, Koza, Kombetiko, Kounden, Lekoung, Lolabe, Maroua,Mbakaou, Mbokaon, Mbouda river, Meanja, Metchum, Meiganga, Mount Cameroon, Mount Manengouba, Molyko, Mokolo, Mpundu, Nachtigal, Ngaoundere, Nkolbisson, Ntui, Obala, Mayo-Darlé, Tibati, Poli, Tombel, Wakwa, Yagoua, Yaounde, Yoko, (ACR, 2017), Maga, Mokolo (Bakwo Fils, personal data).

Lissonycteris angolensis Bocage, 1898

A single male and a single female were mist nested at a drinking site in the forest area of the Park. This species is listed as LC in the IUCN Red List and its population trend is unknown (Bergmans et al., 2017). This forest species was previously recorded in Buea (Matchie, 1891), Bibundi, Bonge, Ndiang, (Sjostedt, 1897a; 1897b), Bimbia, Tombel (Eisentraut, 1942), Eseka (Haiduk et al., 1981), Ngaoundere (Muller et al., 1981), Dja Reserve (Bakwo Fils, 2009a). Specimens currently kept in museums were collected in Bafut, Banyo, Boukma, Buea, Campo, Djohong, Eseka, Galim, Gwofong, Lolabe, Mayo Darle, Kombe, Kounden, Koutaba, Koza, Kribi, Lekoung, Mbakaou, Mbokoan, Meanja, Meiganga, Moliko River, Mount Manegouba, Mokolo, Mpundu, Ngaoundere, Ntui, Nachtigal, Obala, Poli, Tibati,

Tiko, Touroua, Tote, Wakwa, Yagoua, Yaounde, Yoko (ACR, 2017) (Fig. 5).

Myonycteris torquata Dobson, 1878

The single male individual was captured in a marshy area, beside a stream within the forest. This forest and savannah species (Fig. 6) is listed as LC in the IUCN Red List and its population trend is unknown (Bakwo Fils & Kaleme, 2016b). This forest species was previously recorded in Ngaoundere (Haiduk et al., 1981), the Natural Reserve of Campo (Cosson, 1995), and Dja reserve (Bakwo Fils, 2009a). Specimens currently kept in museums were collected in Aboulou, Belabo, Bertoua, Bityé, Bota, Buea, Campo, Dimako, Eseka, Ebolowa, Kanyol, Koutaba, Kumba, Lake Barombi, Lake Tissongo, Lolodorf, Lomié, Mesea, Meyo, Mey Joss, Nkoulou, Nguilili, Ngoume, Ntui, Ngobilo, Yaoundé (ACR, 2017).

Rousettus aegyptiacus Geoffroy St.-Hilaire, 1810

This species is widely distributed in the western part of Cameroon (Fig. 7) and it is recorded to come from natural forest gaps in the northern part of the park. Two individuals were captured at drinking sites (rivers) (sites 6 and 9). In the northern periphery of the park, six other individuals were caught in a cave (site 14) that contained more than 300 individuals. All the adult females carried a young as they escaped from the cave. This species is listed as LC in the IUCN Red List and its population trend is unknown (Korine, 2016). This forest species was previously recorded in Buea (Sanborn, 1936), Mamfe (Sanderson, 1940), Kilum-Ijim forest (Maisel et al., 2001), Dja reserve (Bakwo Fils, 2009b). Specimens currently kept in museums were collected in Bafut, Bamenda, Bipindi, Bota, Boteke Village, Campo, CDC Banana Plantation, Dokoa, Ekona, Great Soppo, Isobi, Lake Barombi, Kribi, Lododorf, Mount Cameroon, Mueli, Mukono, Ngoume, Sakbayeme, Tiko, Toura, Tombel, Yaounde (ACR, 2017).

Insectivorous bats

Rhinolophus alcyone Temminck, 1853

This species was recorded in the northern part of the park and it is less widely distributed in Cameroon (Fig. 8). The single female individual was captured across a river in the forest. This species is listed as LC in the IUCN Red List and its population trend is unknown (Monadjem et al., 2017a). This forest species was previously recorded from Mamfe (Sanderson, 1940), Nyasosso, Mount Kupe, Wildi cave, Buena, Nkoetye (Perret & Aellen, 1956), Mount Cameroon (Eisentraut, 1964). Specimens currently kept in museums were collected in Boteke Village, Bokwango, Bova Village, Eseka, Gwando, Meyo, Moloko, Moungo, Mpundu, Muyuka, Nkoetye, Nkoulou, Soppo, Soumo River, Soppo (ACR, 2017) (Fig. 8).

Hipposideros cyclops Temminck, 1853

This species is widely distributed in the southern part of the country (Fig. 9). Three individuals (1 female and 2 males) were captured in the northern part of the park beside a river (site 6) and in a dead tree trunk (site 12). This species is listed as LC in the IUCN Red List and its population trend is unknown (Monadjem et al., 2017b). This forest and savannah species was previously recorded on Mount Cameroon (Dobson, 1878), Buea (Matschie, 1891), Kita (Sjostedt, 1897b), Efoulen (Allen, 1922), Besongabang, Okoiyong, Eshobi , Bashauo, Atolo, Tinta, Bitye (Sanderson, 1940), Mubenge-Isongo (Eisentraut, 1942), Kribi, Akak (Aellen, 1952), Dja Reserve (Bakwo Fils, 2009a), Camp II, Mount Kupe (Hill, 1968), Ngam, Meyo, Ambam (Perret & Aellen, 1956). Specimens currently kept in museums were collected in Bebai, Bele, Bertoua, Bipindi, Bokwango, Buea, Bunduma Village, Ebolowa, Efulen, Eseka, Isongo, Kribi, Lake Muyuka, Lombe, Mengueme, Metet, Meyo, Mieri, Muyuka, Nkoulou, Ngoume, Ndjole, Olounou, Sangmelima, Sakbayeme, Tisongo, and Zulabot II (ACR, 2017) .

Hipposideros fuliginosus Temminck, 1853

This species is found in both the forest and the savannah in the northern part of the park. Seventeen individuals (9 females and 8 males) were caught at a drinking site (small stream) in the forest (sites 6 and 9) and in a savannah cave (site 13) that contained more than 200 individuals. This species is listed as LC in the IUCN Red List and its population trend is unknown (Monadjem et al., 2017c).

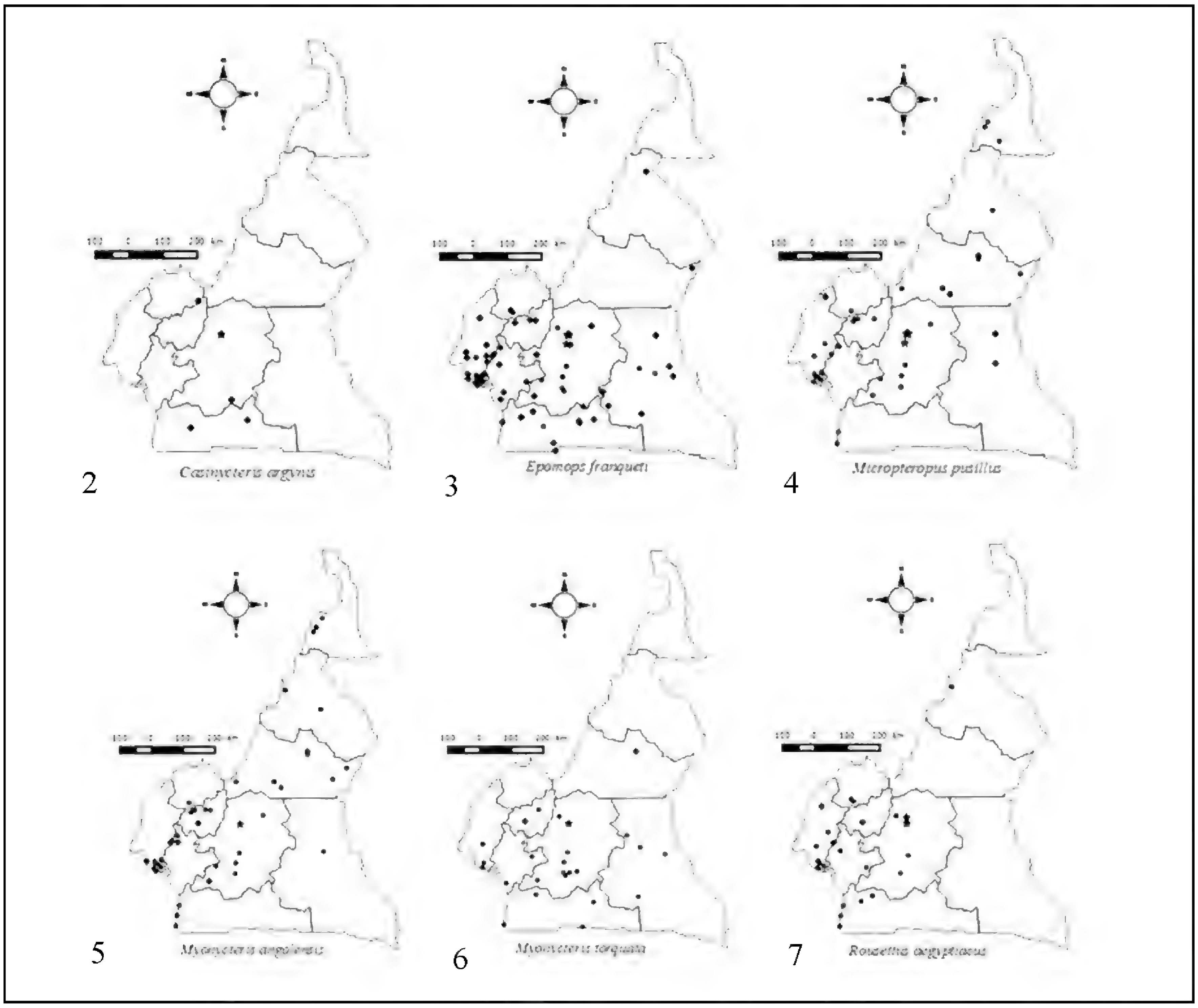
This species was previously recorded in the Mungo (Peters, 1876), Victoria (Sjostedt 1897b), Sakbayeme (Allen, 1921), Ndikiniméki (Aellen, 1952), Dja Reserve (Bakwo Fils, 2009a). Specimens currently kept in museums were collected in Mamfé, Kumba, and Kribi (ACR, 2017) (Fig. 10).

Hipposideros ruber Noack, 1893

This species was caught in the north and south of the forest as well as in the northern periphery of the park. Ninety-seven individuals were caught in 5 sites (2, 3, 5, 9, and 6), all located in the forest. It is the most abundant and was caught in a living tree cavity and along a river. This species is listed as LC in the IUCN Red List and its population trend is unknown (Monadjem et al., 2017d). This forest and savannah (Fig. 11) species was previously recorded in Jauro Massali (Hutterer et al., 1992), Kilum-Ijim (Maisel et al., 2001), Dja Reserve (Bakwo Fils, 2009a), Makot (Bakwo Fils, personal data). Specimens currently kept in museums were collected in Bertoua, Bipindi, Bitye, Buea, Campo, Ebolowa, Efulen, Eseka, Kribi, Kumba, Lake Barombi, Lomie, Mamfe, Mbalmayo, Mount Cameroon, Nanga Eboko, Poli, Mieri, Sakbayeme, Sangmelima, and Telo (ACR, 2017).

Nycteris grandis Peters, 1865

This species was caught in a swampy area beside a river in the forest (site 7) in the northern part of



Figures 2–7. Distribution maps of the different species caught in the Mpem and Djim N. P. in Cameroon. Star = capture point in the park, dot = capture points of the specimens in the museum and other capture points reported in Cameroon). Fig. 2: *C. argynis*. Fig. 3: *E. franqueti*. Fig. 4: *M. pusillus*. Fig. 5: *M. angolensis*. Fig. 6: *M. torquata*. Fig. 7: *R. aegyptiacus*.

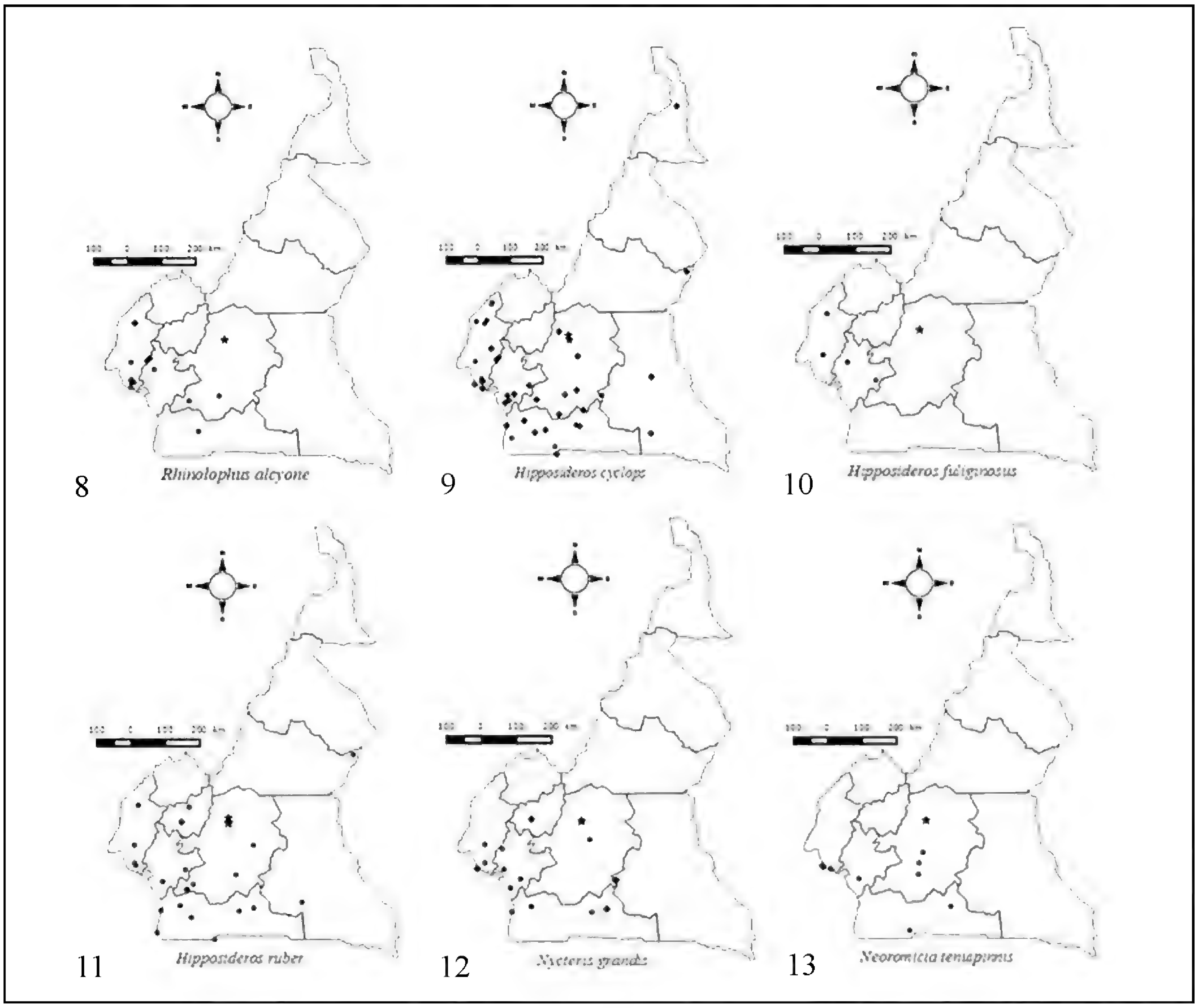
the park. It is listed as LC in the IUCN Red List and its population trend is unknown (Monadjem et al., 2017e). This forest and savannah (Fig. 12) species was recorded in Bitye (Andersen, 1912), Mubengue-Isongo (Eisentraut, 1942), Myntyaminyumin, Ngam (Perret & Aellen, 1956), Dja Reserve (Bakwo Fils, 2009a). Specimens currently kept in museums were collected in Bitye, Bipindi, Bonge, Douala, Edea Game Reserve, Kumba, Kribi, Lumbindu, Malende Swamp Area, Myntjaminyumin, Mount Cameroon, Ngam, Ndjole, Njombo River, Sangmelima, and Tisongo (ACR, 2017).

Neoromicia tenuipinnis Peters, 1872

This species is found in the forest, in the northern part of the park. Two male individuals of this forest and savannah species were caught at the drinking sites. *Neoromicia tenuipinnis* is listed as LC in the IUCN Red List (Monadjem & Fahr, 2017a). It was previously recorded in Ambam, Yaounde (Mc Bee et al., 1987), Isongo, Debundscha, Bota (Eisentraut, 1942). Specimens currently kept in museums were collected in Ambam, Bitye, Bota, Boteke Village, Isongo, Kumba, Mawutu, Yaounde, Meanja, Muyuka, Ntui, and Obala (ACR, 2017) (Fig. 13).

Glauconycteris egeria Thomas, 1913

The single male individual of this species was caught in the southern part of park in the forest be-

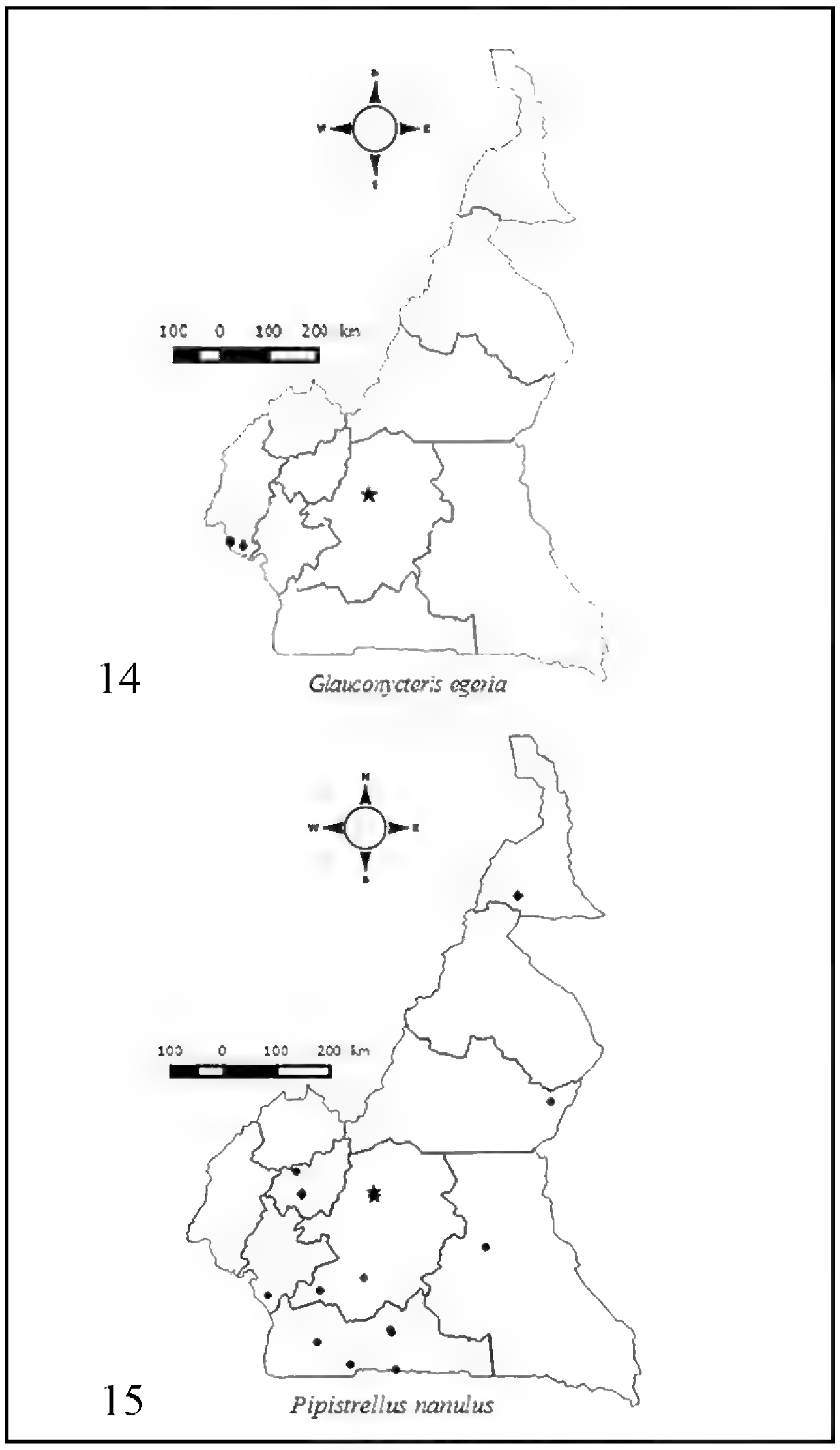


Figures 8–13. Distribution maps of the different species caught in the Mpem and Djim N. P. in Cameroon. Star = capture point in the park, dot = capture points of the specimens in the museum and other capture points reported in Cameroon). Fig. 8: *R. alcyone*. Fig. 9: *H. cyclops*. Fig. 10: *H. fuliginosus*. Fig. 11: *H. ruber*. Fig. 12: *N. grandis*. Fig. 13: *N. tenuipinnis*.

side a river. It is listed as DD in the IUCN Red List and its population trend is unknown (Jacobs et al., 2008). This forest species was previously recorded in Bibundi and Buea (ACR, 2017) (Fig. 14).

Pipistrellus nanulus Thomas, 1904

This species was caught in the northern part of park, in the forest and savannah. Nine male individuals were captured beside a river in the forest (site 6) and in the savannah (site 4). *Pipistrellus nanulus* is listed as LC in the IUCN Red List (Monadjem & Fahr, 2017b). The distribution map (Fig. 15) shows that *P. nanulus* is a forest and savannah species. Van Cakenberghe & Happold (2013) also suggest that this species seems to prefer both forest and savannah zones as well as boundaries between the two. This ubiquitous species was previously recorded in Efulen (Rosevear, 1965), Dja Reserve (Bakwo Fils, 2009b), and Maroua (Aaron Manga, 2012; Bakwo Fils et al., 2014). Specimens currently kept in museums were collected in Aboulou, Ambam, Dimako, Eseka, Foulassi, Galim, Njombo River, Lake Tissongo, Sangmelima, and Yaounde (ACR, 2017).



Figures 14, 15. Distribution maps of the different species caught in the Mpem and Djim N.P. in Cameroon. Star = capture point in the park, dot = capture points of the specimens in the museum and other capture points reported in Cameroon). Fig. 14: *G. egeria*. Fig. 15: *P. nanulus*.

DISCUSSION

Bats constitute one of the most ecologically diverse groups of vertebrates of the Mpem and Djim National Park. These animals play an important role in the functioning of the ecosystem. Insectivorous bats regulate insect populations, of which some are agricultural pests. Fruit bats disperse seeds and help maintain forest diversity (Fahr et al., 2002). This function suggests the important role bats play and their absence would impoverish the ecosystems of which they are a part of. This ecological importance may likely explain the spread of these species on the whole territory, characterized by several biogeographical zones.

The bat community of this park harbours species which rely on caves (*R. aegyptiacus* and *H. fuliginosus*) as well as holes in trees (*H. cyclops* and *H. ruber*). Several favourable habitats exist for bats at the Mpem and Djim National Park. However, these habitats are threatened by the ineffective management of the park and thus favouring human action which may be harmful to the bats. These anthropic actions include bush fire caused by herdsmen, deforestation for the plantation of cocoa, etc. With the exception of *G. egeria*, which is DD in the IUCN Red List, all species captured at the study site are Least Concern in the IUCN Red List. These anthropic activities may endanger the conservation of bat species composition at the Mpem and Djim National Park Community.

Most of the captured species at the park are forest species, except *M. pusillus* and *L. angolensis,* which are cosmopolitan in Cameroon. They have been recorded in the ten administrative regions of the country. Thus, they are species of the south tropical forest, of the humid savannah in the Centre, and of the dry savannah in the Far North. It is interesting

Species	Numbers of individuals per study site														Total
	site 1	site 2	site 3	site 4	site 5	site 6	site 7	site 8	site 9	site 10	site 11	site 12	site 13	site 14	14
Fruit bats															
Casinycteris argynnis	0	0	0	0	0	0	0	0	0	0	1	0	0	0	**1**
Epomops franqueti	0	1	0	0	0	0	0	0	0	1	4	0	0	0	**6**
Micropteropus pusillus	7	0	0	0	0	3	0	4	3	0	0	0	0	0	**17**
Myonycteris angolensis	0	0	0	0	0	0	2	0	0	0	0	0	0	0	**2**
Myonycteris torquata	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**
Roussettus aegyptiacus	0	0	0	0	0	1	0	0	1	0	0	0	0	6	**8**
Insectivorous bats															
Rhinolophus alcyone	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**
Hipposideros cyclops	0	0	0	0	0	2	0	0	0	0	0	0	0	0	**3**
Hipposideros ruber	0	7	82	0	1	0	0	0	1	0	0	0	6	0	**97**
Hipposideros fuliginosus	0	0	0	0	0	1	0	0	1	0	0	0	15	0	**17**
Nycteris grandis	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**
Neoromicia tenuipinnis	0	0	0	0	0	0	0	0	2	0	0	0	0	0	**2**
Glauconycteris egeria	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Pipistrellus nanulus	0	0	0	6	0	3	0	0	0	0	0	0	0	0	**9**
Total individual	**7**	**9**	**82**	**6**	**1**	**10**	**4**	**4**	**9**	**1**	**5**	**7**	**15**	**6**	**166**
Total species	**1**	**3**	**1**	**1**	**1**	**5**	**3**	**1**	**6**	**1**	**2**	**2**	**1**	**1**	**14**
Effort for 12 metres/night	**20.8**	**28.6**	**24.7**	**28.6**	**14.3**	**14.3**	**14.3**	**14.3**	**14.3**	**14.3**	**14.3**	**14.3**	**14.3**	**7.8**	**239.2**
capture success /night	**0.33**	**0.31**	**3.32**	**0.21**	**0.07**	**0.7**	**0.28**	**0.28**	**0.63**	**0.07**	**0.35**	**0.49**	**0.07**	**1.3**	**0.69**

Table 2. Sampling effort, capture success, and specific abundance of bats in the Mpem and Djim National Park, Cameroon.

to note that *M. pusillus* was recorded in the forest, savannah, and ecotone zones of the park. This is similar to the results of Fahr (1996) in Ivory Coast who recorded 69% of this species at the savannah, 18% at the ecotone, and 12% at the forest. *E. franqueti*, *M. torquata, R. aegyptiacus*, *H. ruber*, *H. fuliginosus*, *N. tenuipinnis*, and *P. nanulus* are found in the tropical forest and the humid savannah. This is in agreement with the works of Napoko et al. (2015) at Burkina Faso who noted the presence of *H. cyclops* in the savannah and forest; Fahr (1996) who sampled 70% of the individuals of *H. ruber* in the forest and 30% in the savanna; Bates et al. (2014) who recorded *N. tenuipinnis* in the two ecosystems in Congo. However, Haiduk et al. (1981) signaled the presence of *L. angolensis* in Adamawa confirming the presence of the species in both ecosystems in Cameroon. *C. argynnis*, *Rhinolophus alcyone*, *H. fuliginosus*, and *G. egeria* were uniquely in the forest zones. These species are few in number in Cameroon and are found in the Southern part of the country. *Casinycteris argynnis* is a solitary and rare species (Happold & Happold, 2013) and only a single individual was captured at the park. A closely related species, *C. campomaanensis*, was discovered in the locality of Campo-Ma'an in the South of the country (Hassanin, 2014). Only two records of *G. egeria* were previously known in the South West region of Cameroon (forest zone). The works of Decher et al. (2016) signal the presence of *H. fuliginosus* in the Mountainous chains of Simandou in Guinea.

CONCLUSIONS

The Mpem and Djim National Park is one of the hotspots for biodiversity conservation in Cameroon. A significant portion of this ecosystem needs greater attention and we recommend the following actions:

biodiversity surveys should be extended in this protected area in order to understand bats ecological requirements and threats, which help in setting up management plans adapted regionally and that allow a targeted use of resources; more targeted surveys and in-depth studies of species listed as endangered or critically endangered according to the International Red List should be carried out; deforestation by a combination of ground assessments and remote sensing should be monitored; bat habitat requirements need to be monitored on a long term basis and legal protection of bats roost and habitats at the park and its surroundings should be included in the management of wildlife species; long streams provide foraging and drinking habitats for bats at the park, and so, creation of bridges with vertical crevices can

Sexes	Lb (mm)	Lf (mm)	Lt (mm)	Le (mm)	Ltr (mm)	Lta (mm)	Weight (g)
Casinycteris argynnis							
Female	72 (n=1)	63	25	20	0	0	11
Epomops franqueti							
Male	(92-130) (n=3)	(100-82)	(33-38)	(20-25)	0	0	(73-131)
Female	(93-104) (n=3)	(85-97)	(33-39)	(20-24)	0	0	(86-109)
Micropteropus pusillus							
Male	(50-63) (n=10)	(42-52)	(18-22)	(13-15)	0	0	(15-29)
Female	(41-68) (n=1)	46-59	16-23	(11-16)	0	0	(16-32)
Myonycteris angolensis							
Male	76 (n=1)	82	35	18	0	16	66
Female	85 (n=1)	82	32	18	0	15	76
Myonycteris torquata							
Female	71 (n=1)	57	31	13	0	12	22
Roussettus aegyptiacus							
Male	108-110 (n=3)	98-99	40-42	16-19	0	(0.8-12)	134-146
Female	105-120 (n=5)	98-102	40-45	19-22	0	15-16	134-148
Rhinolophus alcyone							
Female	55 (n=1	53	24	19	0	22	15
Hipposideros cyclops							
Male	(64-66) (n=2)	(69-70)	(32-35)	(22-28)	0	(26-32)	(28-40)
Female	70 (n=1)	66	34	25	0	25	30
Hipposideros ruber							
Male	(45-55) (n=44)	(50-60)	(19-24)	(09-17)	0	(19-32)	(10-17)
Female	(42-55) (n=53	(50-60)	(19-24)	(10-17)	0	(22-32)	(0.8-14)
Hipposideros fuliginosus							
Male	(39-44) (n=8)	(50-52)	(20-24)	(10-15)	0	(30-35)	(0.9-24)
Female	(40-47) (n=9)	(50-52)	(21-23)	(11-14)	0	(30-33)	(0.8-10)
Nycteris grandis							
Male	58 (n=1)	62	34	33	0	70	24
Neoromicia tenuipinnis							
Male	(32-34) (n=2)	(30-31)	(10-11)	(0.7-10)	0	(25-27)	(0.2-0.5)
Glauconycteris egeria							
Male	39 (n=1)	38	18	12	5	32	6
Pipistrellus nanulus							
Male	(25-35) (n=4)	(26-30)	(0.9-19)	(0.7-0.9)	0	(11-30)	(0.2-0.3)

Table 3. Measurements of the different parameters of the species caught in the park. Lb: total body length, Lf: length of forearm, Lt: length of tibia, Ltr: length of tragus, Lta: length of tail, Le: length of ear, n: number of individual.

Localities	Latitude	longitude	Localities	Latitude	longitude	Localities	Latitude	longitude	localities	Latitude	longitude
Aboulou	2.3	12.05	**Dokoa**	4.36667	11.73333	**Lomié**	3.16667	E13.61667	**Nanga Eboko**	4.68333	12.36667
Akak	5.48333	9.36667	**Douala**	3.75528	9.94472	**Mabeta**	3.98854	9.28936	**Ndiang**	4.7697	9.8719
Akon	5.75979	9.06448	**Ebolowa**	3.9	11.9	**Makot**	3.5	E10.6	**Ndikinimeki**	4.76667	10.83333
Ambam	2.38333	11.28333	**Edea**	3.8	10.13333	**Mamfe**	5.754	E9.3123	**Ndjole**	4.81667	11.93333
Atolo	6.22548	9.49478	**Efulen**	2.76667	10.71667	**manengouba**	4.9522	E9.8678	**Ngam**	3.76667	12.58333
Ayos	4.08333	11.28333	**Ekona**	5.0288	9.4924	**Mang**	5.45681	10.30582	**Ngaoundere**	5.26667	14.01667
Bafut	5.89649	10.20066	**Ekundu**	4.6884	8.96506	**Mangamba**	4.2456	9.4344	**Ngobilo**	4.33333	10.61667
Bamenda	5.95971	10.14597	**Eseka**	3.65	10.76667	**Mayo Darle**	6.46667	E11.55	**Ngoume**	5.48333	11.4
Banyo	4.48333	14.01667	**Eshobi**	5.78583	9.36027	**Mbakaou**	6.31667	E12.81667	**Njombo**	4.58056	9.66472
Batanga	4.16667	14.46667	**Foulassi**	2.98333	11.96667	**Mbalmayo**	3.72361	E9.955	**Nkoulou**	3.78333	11.56667
Batouri	4.43333	14.36667	**Galim**	5.68955	10.3672	**mbouda**	5.62611	E10.25421	**Ntui**	4.45	11.63333
Belabo	4.93333	13.3	**Garoua**	10.2281	14.81743	**Meanja**	4.265000	9.396700	**Obala**	4.16667	11.53333
Bele	11.47917	14.79679	**Idenau**	4.240500	8.991200	**Mefo**	2.96667	11.96667	**Olounou**	3.36667	12.08333
Bertoua	7.03879	15.00753	**Ikiliwindi**	4.7317	9.4881	**Meiganga**	6.51667	14.3	**petit Batanga**	3.19861	9.92667
Besongabang	5.70735	9.29875	**Isobi**	4.12068	8.99244	**Mengueme**	3.25000	11.400000	**Sakbayeme**	4.03333	10.56667
Bibundi	4.2191	8.9876	**Isongo**	4.0687	9.0164	**Metet**	2.18333	11.33333	**Sangmelima**	2.933333	11.983333
Bimbia	3.95444	9.245	**Itoki**	4.83003	8.94229	**Meyo**	2.83333	11.01667	**Somalomo**	3.38333	12.73333
Bipindi	3.08333	10.41667	**Kita**	4.6861	9.0324	**Mieri**	4.25	13.98333	**Soppo**	4.1517	9.2514
Bityé	3.01667	12.36667	**Klein**	3.19861	9.92667	**Mokolo**	10.74244	13.80227	**Tibati**	6.46504	12.62843
Bokwango	4.1349	9.222	**Kombe**	4.08333	E10.96667	**Moliko**	4.1529	9.285	**Tiko**	4.0745	9.3699
Bota	4.0197	9.1956	**Kounden**	5.70311	E10.66639	**Moungo**	4.5	9.83333	**Tinta**	6.2722	9.511
mboukma	8.52173	13.9766	**Koutaba**	5.685403	E10.810337	**Mont Cameroun**	4.216503	9.213773	**Tisongo**	3.568056	9.876111
Buea	4.1527	9.241	**Koza**	10.86846	E13.88205	**Mont Kupe**	4.801400	9.708100	**Tombel**	4.7466	9.6705
Campo	2.36667	9.81667	**Kribi**	2.95	E9.91667	**Mpundu**	4.2356	9.4108	**Touroua**	9.08333	12.96667
Debundscha	4.1007	8.9786	**Kumba**	4.6921	E9.2097	**Muea**	4.1749	9.3044	**Victoria**	4.0242	9.2149
Dimako	4.38333	13.56667	**Lolabe**	2.66667	E9.85	**Mukonje**	4.5776	9.5067	**Wakwa**	7.23333	13.58333
Dja	5.30718	10.46168	**lolodorf**	3.23333	E10.73333	**Mukono**	4.6283	9.1658	**Yagoua**	10.34107	15.23288
Djohong	6.83333	14.7	**Lombe**	3.63389	E9.98611	**Muyuka**	4.7251	9.6342	**Yaounde**	3.866667	11.516667
									Yoko	5.53333	12.31667

Table 4. Gazetteer of localities listed in the text.

provide ideal roosting sites when they spun such waters; access to vulnerable caves in the park and its surroundings should be restricted. Furthermore, it is important to create and maintain ponds for managing bats and other wildlife across the Mpem and Djim National Park Forest landscape.

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Infralittoral molluscs from the Scilla cliff (Strait of Messina, Central Mediterranean)

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ABSTRACT The mollusc taxocoenosis characterizing the photophilic zone of the Scilla cliff (Strait of Messina, Central Mediterranean) has been described on hard bottom samples from 6, 16 and 24 m depth. Seasonality has been evaluated by replicates carried out in autumn and spring. Overall, 229 benthic taxa have been recorded, 87 of which occurred in both seasons, while 109 were exclusively recorded in spring and 29 only in autumn. Specimen abundance also notably decreased from autumn to spring (1581 and 892 individuals, respectively). Depth scarcely affected the species distribution, probably due to water transparency, thermal homogeneity, and nutrient mixing. The recorded species cannot be all assigned to the photophilic rocky habitat, since ubiquitous taxa, organisms of other habitats settled in micro-enclaves, and juveniles of not established species have been frequently recorded. The role of algal covering as larval collector from disparate habitats is confirmed, as also proved by the high occurrence of planktonic molluscs (14 species) in all the examined samples. The whole mollusc taxocoene, whose diversity is high with respect to other areas at comparable latitudes, showed a marked western footprint, in accordance with the known biogeographic peculiarities of the Messina Strait.

KEY WORDS Biodiversity; benthos; molluscs; Mediterranean; coastal environment.

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INTRODUCTION

Mediterranean biodiversity has in the Strait of Messina (MS) one of the most relevant hot spot. High diversity is here coupled with peculiar associations which made necessary to consider such area as a distinct "microsector" inside the biogeographical Mediterranean subdivision (Bianchi et al., 2012).

Molluscs are probably the most known Phylum from the MS area, counting 827 species in the updated check-list of Italian seas (http://www.sibm.it/CHECKLIST/menu%20checklist%20I.htm). Present knowledge, nevertheless, suffers the lack of extensive studies, so that only some major taxa and habitats, as the "Opisthobranch fauna" from brackish areas, have been exhaustively investigated (Vitale et al., 2016). Hard bottom mollusc biodiversity, in the Sicilian MS side has been explored on the local scale in the upper Infralittoral of Messina, (Cosentino & Giacobbe, 2015). In the Calabrian side, the Infralittoral mollusc taxocoene has been recently investigated in the Capo d'Armi cliff, south of Reggio Calabria (Giacobbe & Renda, 2018). The Scilla cliff, north of Reggio Calabria, has been frequently cited in malacological literature and in re-

cent years has provided several new mollusc species and some probable endemism (Bogi & Campani, 2007; Buzzurro & Russo, 2007; Bogi & Bartolini, 2008; Tisselli et al., 2009; Smriglio & Mariottini, 2013; Romani & Scuderi, 2015). Some attention also received the spreading of not native species (Crocetta et al., 2009). Current knowledge, nevertheless, is almost inorganic, as it refers to records that in general are not adequately contextualized, or carried out without a precise sampling plan (see Vazzana, 2010).

First data on the mollusc taxocoenosis, that characterize the photophilic zone of the Scilla cliff, are reported in this paper, as a contribution to the knowledge of the mollusc local biodiversity. The aim of the study is to provide a baseline for monitoring benthic assemblages of this crucial area, which could dramatically be affected by ongoing climate change.

MATERIAL AND METHODS

Study area

The Scilla cliff (Fig. 1), known since the most ancient age due to the strong currents and whirls making dangerous the navigation (Androsov et al., 1996), delimits the northern mouth of the MS into the Calabrian side. Widely described and figured in the popular literature, it has been widely investigated in the geological and seismological field (Ferranti et al., 2007; Casalbore et al., 2014), but very few studies have been carried out about the seabed ecology. Quantitative data on benthic assemblages from a granitic shoal at 35–60 m depth, have been focused on gorgonians (Mistri & Ceccherelli, 1994) and their mass mortality (Mistri & Ceccherelli, 1995). Infralittoral hard bottom assemblages have been investigated with methodological purposes, but without providing lists of species (Mistri & Rossi, 2000).

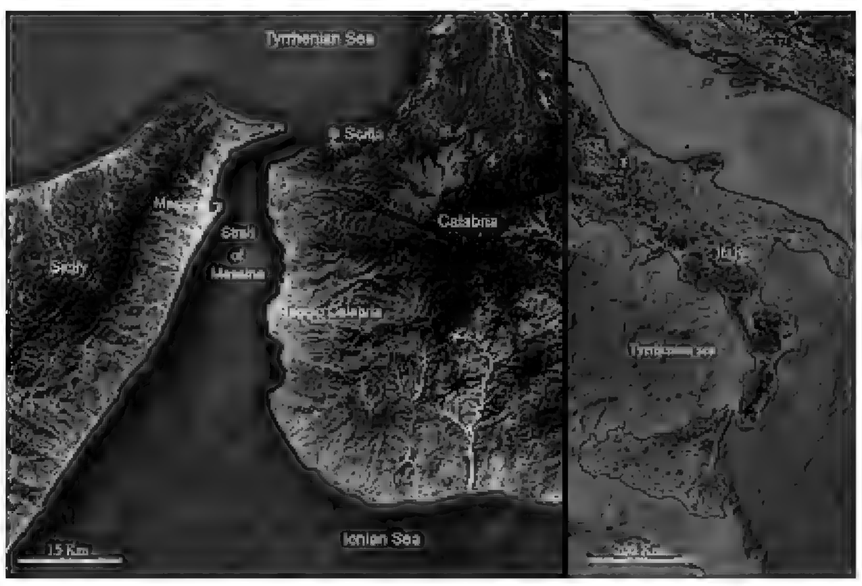

Figure 1. Study area.

Sampling

The investigations concerned three sites, located about 200 m away from each other. In each site, three bathymetric levels (6, 16, and 24±2 m depth) were sampled, each performed by three replicates about 20 m away from each other. Sampling has been repeated in autumn (I time) and spring (II time), to evaluate seasonality. The samples were collected by scraping 30x30 cm surface of rocky substrate, separately gathered in 0.1 mm mash sampling nets, and stored in ethanol 75%. In laboratory, mollusc fauna was sorted under stereomicroscope and the specimens determined at species level, as far as possible. Abundance of taxa per sample was evaluated on the three replicates pooled. Pelagic gastropods trapped in the algal covering, have also been sorted and classified, and qualitative data have been reported as a further contribution to the mollusc local biodiversity.

Most relevant species have been photographed by means of USB DCM130 digital camera mounted on a binocular microscope, and the photos processed by Photoshop software.

Nomenclature followed WoRMS (http://www.marinespecies.org/), updated at 2018-06-30.

RESULTS

Benthic species

Overall, 2473 living specimens have been collected from the mollusc taxocoenosis, belonging to 229 benthic taxa, 208 of which determined at the species level (Table 1). The species were almost irregularly distributed between the two seasons, strongly decreasing from autumn to spring (196 and 116 species, respectively). Specimen abundance also notably decreased (1581 and 892 individuals, respectively). A total of 87 established taxa was in-

dividuated, whilst 109 taxa were exclusively recorded in spring compared to the 29 ones found in autumn. The greatest part of not established taxa counted a low number of specimens, 63 of which, since represented by a specimen alone, should be considered as occasional.

A marked seasonality, by contrast, might characterize some of the not established species which counted more than 10 individuals (Fig. 2), namely the autumnal *Chauvetia lefebvrii* (Maravigna, 1840), *Pusillina inconspicua* (Alder, 1844), *Striarca lactea* (Linnaeus, 1758), *Eatonina ochroleuca* (Brusina, 1869), and the vernal *Rissoella diaphana* (Alder, 1848), *Setia turriculata* Monterosato, 1884, *Sinezona cingulata* (Costa O.G., 1861), *Setia* cfr. *turriculata*. The latter two species are present in figure 2, since they account for more than 20 individuals. The problematic taxon *Setia* cfr. *turriculata*, in particular, is the third most abundant species, after *Alvania lineata* Risso, 1826 and *Bittium latreillii* (Payraudeau, 1826) (175 and 126 individuals, respectively). None of the 34 most abundant species were found exclusively in the autumn.

The bathymetric distribution, as detailed in Fig. 3, showed weak differences between 6, 16, and 24 m depth levels, sharing 48 species, including the 22 most abundant ones (≥32 specimens). The first, *Bittium latreillii*, second, *Alvania lineata*, fourth, *Retusa truncatula* (Bruguiere, 1792), and fifth (*Haminoea* sp.) most abundant taxa, showed nevertheless a marked prevalence at the deeper level, unlike the third, *Setia* cfr. *turriculata*, and sixth taxa, *Cerithium renovatum* Monterosato, 1884, which dominated at the shallower depth. Among the other twelve most abundant taxa (≥20 specimens), ten species settled more or less preferentially at -6 m, whilst *Tritia cuvierii* (Payraudeau, 1826) and *Setia ambigua* (Brugnone, 1873) were equally abundant from -6 m to -24 m (the latter one was scarce at intermediate depth).

The total number of benthic mollusc species, S, and individuals, N, according to season and depth, is shown in figure 4. Seasonality notably affected abundances, higher in autumn than in spring (1582 and 1043 individuals, respectively). Average abundance regularly increased with depth in autumn, from -6 m (76.0±33.5 ind./site) to -24 m (277.7±20.8 ind./site). A different trend has been observed in spring, since the lowest values have been recorded at -12 m (61.7±32.7 ind./site) and the highest ones at -24 m (204±131.2 ind./site). The number of species also increased with depth, although less markedly in spring (min 20.0±10.2; max 49.3±18.0) rather than in autumn (min 22.7±11.4; max 93.7±8.4).

The Shannon diversity index H' also showed the highest values in autumn, gradually increasing with depth in both seasons (Fig. 5). The minimum (2.1±0.6) was recorded in spring, at 6 m depth, while the maximum (4.1±0.1) in autumn, at 24 m depth. Equitability J' index was uniformly high in autumn, ranging from 0.86±0.0 at -6 m, to 0.9±0.0 both at 12 and 24 m, whilst it was more variable in spring, with minimum at -6 m and maximum at -12 m (0.7±0.1 and 0.9±0.0, respectively).

All the most abundant and/or frequent taxa found in the subtidal cliff of Scilla are widely represented in the whole Mediterranean Sea, but a secondary cluster of west Mediterranean characteristic species is also recognizable. The marginellids *Granulina marginata* (Bivona, 1832) e *Gibberula philippi* (Monterosato, 1878), for example, are known in the western basins (Gofas, 1990; Boyer et al., 2002), although unconfirmed records have been given from some eastern localities (Özturk et al, 2014). The occurrence of both species in the MS has been recently reported for Capo d'Armi by Giacobbe & Renda (2018), which suggested as *Gibberula philippi* "*might be represented by a not yet investigated species complex*".

Some other species, although quantitatively negligible, provide further indications of a marked western affinity, as for example the Caraibic sea hare, *Aplysia parvula* Mörch, 1863, whose present record from Scilla after that of Capo d'Armi (Giacobbe and Renda, 2018) suggested the species is widely present in the MS area. The same symmetric occurrence in Scilla and Capo d'Armi has concerned the amphi-atlantic ascoglossan *Ascobulla fragilis* (Jeffreys, 1856).

Another poorly known species is *Pyrunculus hoernesi* (Weinkauff, 1866), having eastern Atlantic distribution and especially reported from the Canarian and Capo Verde (Tringali, 1993; Ortea et al., 2009). The present record confirmed the occurrence of this species in the MS, that before now could only be deduced from the young specimens figured by Scaperrotta et al. (2011).

Ammonicera nodulosa Oliver et Rolán, 2015, from Spanish Atlantic, has been later reported from

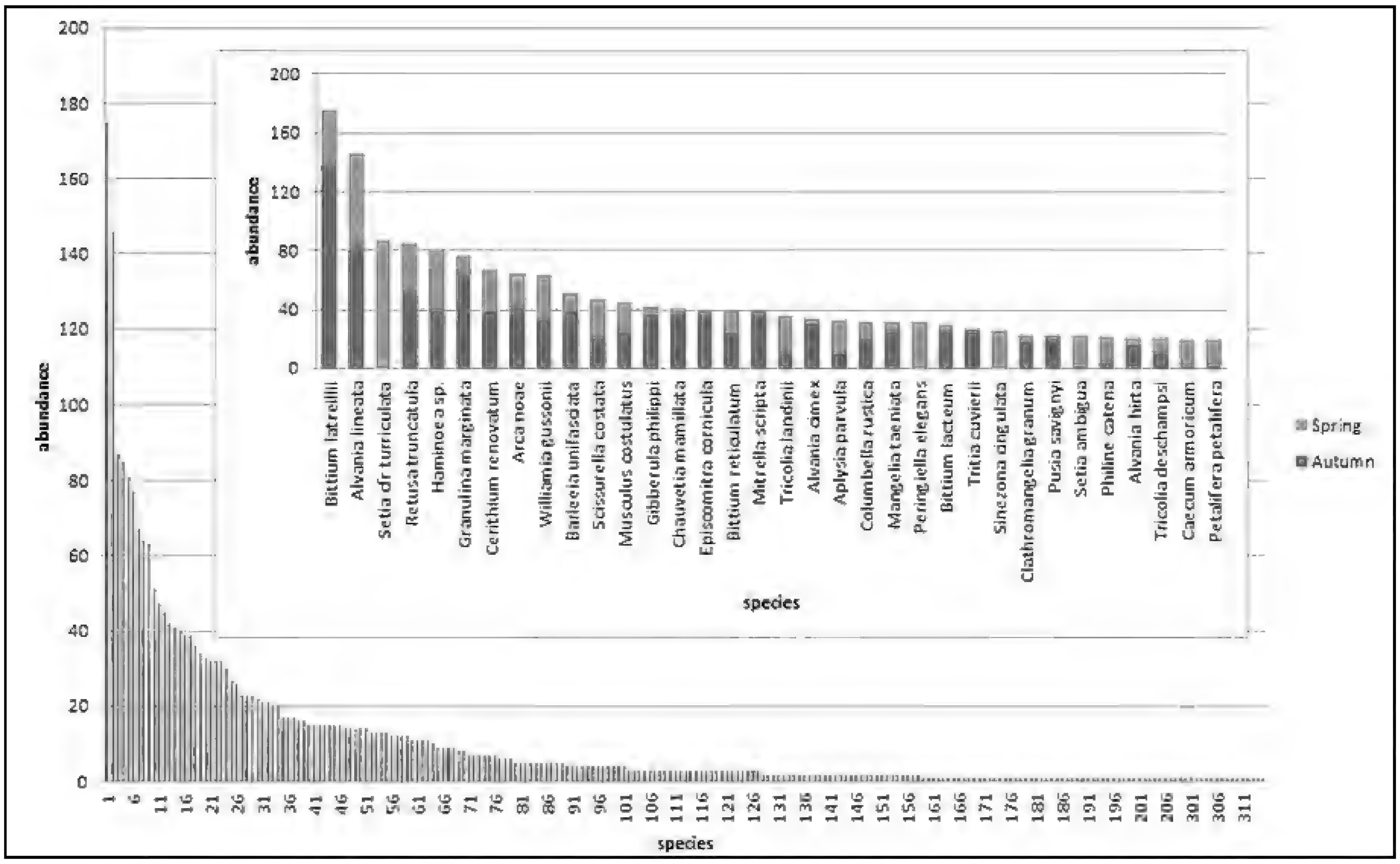

Figure 2. Rank ordination of species (decreasing number of specimens for species) and detail of the 22 most abundant species (> 20 specimens), according to their spring (red) and autumn (blue) abundance.

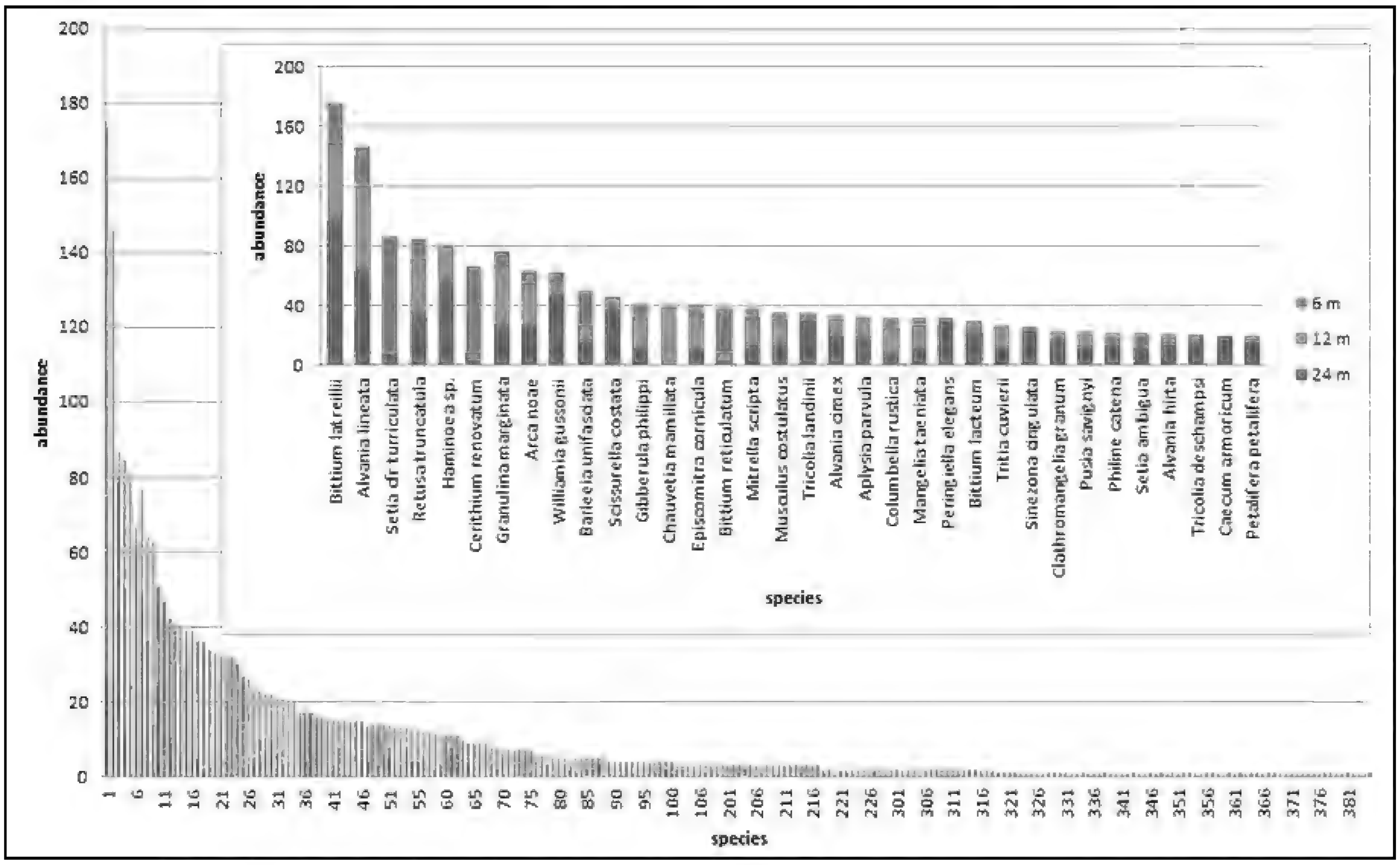

Figure 3. Rank ordination of species (decreasing number of specimens for species) and detail of the 22 most abundant species (> 20 specimens), according to the lower (green), intermediate (red), and deeper (blue) bathymetric levels.

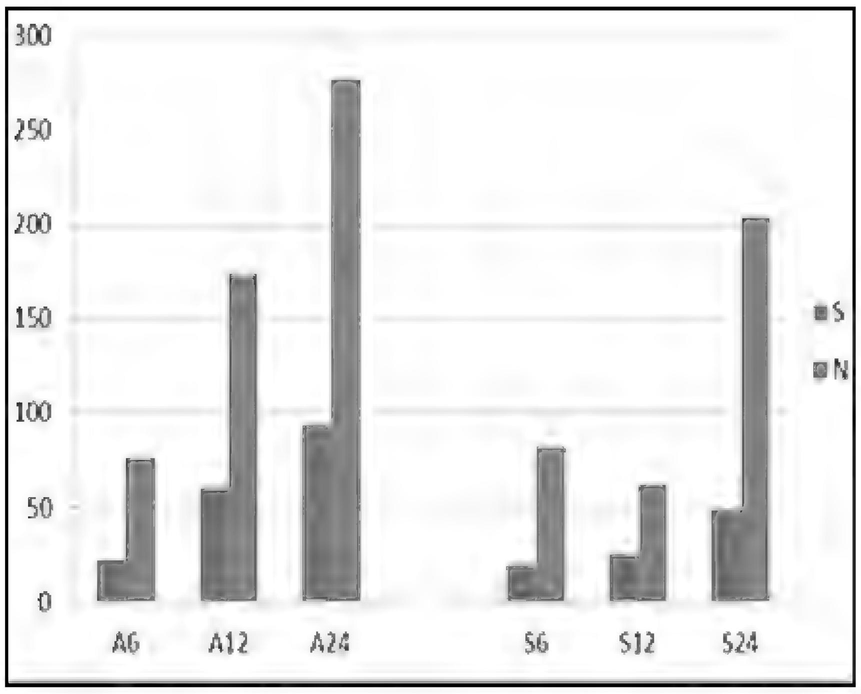

Figure 4. Total number of benthic mollusc species, S, and individuals, N, according to season (A: autumn; S: spring) and bathymetric level (6, 12, 24 m).

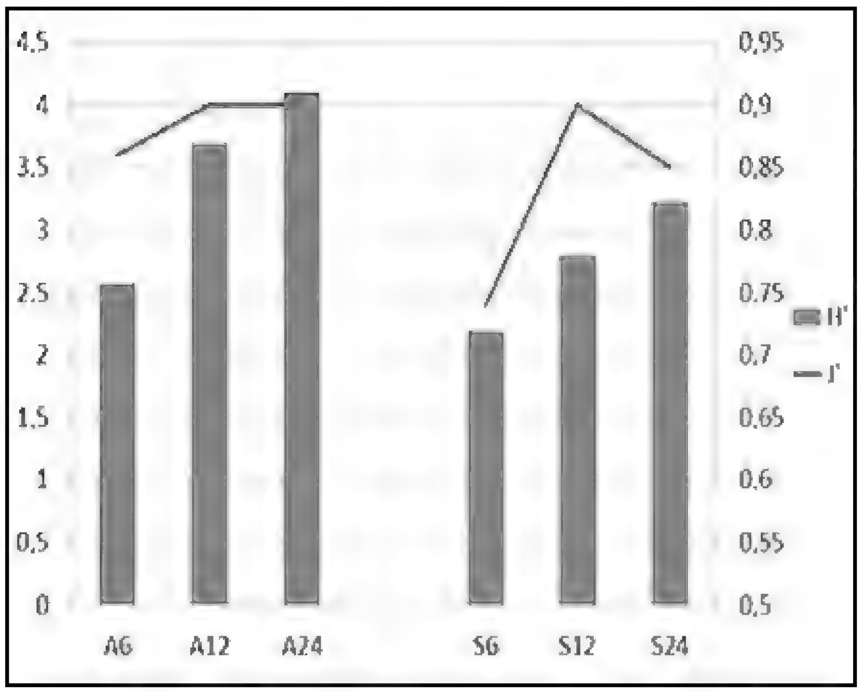

Figure 5. Shannon diversity index, H', and Equitability J', according to season (A: autumn; S: spring) and bathymetric level (6, 12, 24 m).

the north-western Mediterranean (Scaperrotta et al., 2018), Ustica, South Tyrrhenian (Micali, 2016) and north-eastern Ionian (Romani et al., 2018). This poorly known species, which might be widely distributed in the Mediterranean, had not been reported before now from the MS, nor from the contiguous Tyrrhenian basin.

Sinezona semicostata Burnay et Rolán, 1990, accepted as valid species after Geiger (2012 a, b), is considered as a characteristic Macaronesian species, recently recorded in the Mediterranean by Micali & Geiger (2015) from Linosa, and by Romani et al. (2017) from Corfù and Scilla. The present record confirmed the not occasional occurrence at Scilla and, more in general, in the MS area.

The pearl oyster, *Pinctada imbricata radiata* (Leach, 1814), a long-term naturalized Lessepsian, is the only species of eastern origin here reported from Scilla. The simultaneous occurrence, both at south (Giacobbe & Renda, 2018) and north ends of the MS, might foreshadow the establishment of a bridgehead for further diffusion in the Tyrrhenian basin. We mention, at last, the small bivalve *Lasaea adansoni*, as a species never reported in Scilla, despite its wide Mediterranean distribution.

Plancton species

A total of 927 specimens testified the occurrence of 14 planktonic taxa, accidentally trapped by algal covering, here reported as a contribution to the knowledge of the overall mollusc diversity in the Scilla area. They included the Littorinimorpha *Atlanta brunnea* J.E. Gray, 1850, *A. helicinoidea* J.E. Gray, 1850, *A. inflata* J.E. Gray, 1850, *A. lesuerii* J.E. Gray, 1850, *A. peronii* Lesueur, 1817, *Oxygyrus inflatus* Benson, 1835 and *Protatlanta souleyeti* (E.A. Smith, 1888); the Pteropoda *Cavolinia inflexa* (Lesueur, 1813), *Clio pyramidata* Linnaeus, 1767 and *Creseis clava* (Rang, 1828); the Thecosomata *Heliconoides inflatus* (d'Orbigny, 1835), *Limacina trochiformis* (d'Orbigny, 1835), *Peracle diversa* (Monterosato, 1875), *P. reticulata* (d'Orbigny, 1835) and *Styliola subula* (Quoy et Gaimard, 1827).

All *Atlanta* species had a circumtropical distribution that includes the Mediterranean Sea, but while *A. peronii* and *A. lesuerii* are known in the whole Mediterranean, *A. inflata* has been reported only in the western basins, differently from *A. brunnea* and *A. helicinoidea* which are confined in the eastern basins (Wall-Palmer et al., 2018). This latter taxon is confirmed for the Italian seas, after a first ascertained record from Scilla (Giacobbe & Renda, 2018). The other atlantidae, *Oxygyrus inflatus* and *Protatlanta souleyeti,* respectively characterize the central-western and central-eastern Mediterranean.

The occurrence in the MS of the panoceanic pteropoda *Cavolinia inflexa* and *Clio pyramidata*, and the amphi-atlantic *Creseis clava*, has been con-

firmed in agreement with Guglielmo et al. (1995), although authoritative sites like WoRMS do not report such species in the central Mediterranean (marinespecies.org/aphia.php?p=taxdetails&id=605988#distributions). A disjoined distribution was also represented by the Thecosomata *Limacina trochiformis* (Rampal, 2017), *Styliola subula*, and the epibathyal *Peracle reticulata* (Rampal, 1975, 2011), whose prior absence in the central Mediterranean might be due to a low investigation effort. *Heliconoides inflatus* in the Mediterranean is known in the western basins. *Peracle diversa*, although distributed in the whole Mediterranean, is here reported for the first time in the MS area.

DISCUSSION AND CONCLUSIONS

A recent review of the Mediterranean benthic mollusc biodiversity (Sabelli & Taviani, 2014), reporting data of Vazzana (2010), has accredited 396 gastropod and 97 bivalve species from the Scilla seafloors. This large amount of species, however, did not describe the local biodiversity, because almost entirely based on shell remains whose origin cannot be verified, similarly to some recently described species whose actual habitat remains unknown (Pusateri et al., 2012; Romani & Scuderi, 2015; Pusateri et al., 2017; etc.). The shallow subtidal habitat of some scarcely known species which have been reported from the same locality has been instead adequately described (Scuderi & Reitano, 2012), as well as that of some non-indigenous taxa (Stasolla et al., 2014). The lack of contextualized data might explain the absence of Scilla and, more in general, of MS, in the recent review of Poursanidis et al. (2016) about the molluscan fauna from the Mediterranean biocoenosis of photophilic algae. The paper, based on dataset updated to the 2012, reported distribution records for 599 species, about fifty of which, in our opinion, should be rejected as not compatible with the Infralittoral rocky shore habitat. The present investigation on the Scilla cliff, that adds 63 more taxa (three polyplacophorans, fifty gastropods, and ten bivalves) to the Poursanidis dataset, remarkably increased the known amount of species which may be found in the Mediterranean photophilic rocky cliff. All these species, nevertheless, cannot be indiscriminately assigned to such habitat, since some of these are ubiquitous taxa, organisms of other habitats settled in micro-enclaves, or juveniles of species structurally extraneous to the photophilic algae environment. The role of algal covering as larvae collector from disparate habitats (Antit et al., 2013; Lolas et al., 2018), in fact, is here proved by the high occurrence of planktonic molluscs in all the examined samples.

Benthic mollusc diversity of photophilic algae from Scilla may be considered very high, in comparison with other areas at comparable latitudes (Chemello & Russo, 1998; Milazzo et al., 2000; Badalamenti et al., 2002; Terlizzi et al., 2003), independently from their protection regime. Inside the MS, the number of species from Scilla is about twice as many as those recently reported for Capo d'Armi, although the number of individuals was almost equivalent (Giacobbe & Renda, 2018). The number of species which significantly contributed to the mollusc taxocoenosis is also higher at Scilla than at Capo d'Armi. Seasonality, characterized by more species and individuals in autumn rather than in spring, has suggested a relatively late larval recruitment. Depth scarcely affected the species distribution, probably due to water transparency, thermal homogeneity, and nutrient mixing (Azzaro et al., 2007).

The whole mollusc taxocoene showed a marked western footprint, in accordance with the known biogeographic peculiarities which include "Pliocene Atlantic remnants and local endemisms" (Bianchi, 2007, and literature herein cited).

Pelagic molluscs, instead, similarly to that observed at the south-eastern mouth of the MS (Giacobbe & Renda, 2018), included species known to be localized in the eastern basin, in accordance with the constant upwelling of the Levantine Intermediate Waters, LIW.

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POLYPLACOPHORA Gray, 1821

LEPTOCHITONIDAE Dall, 1889
Leptochiton cfr *cancellatus* (Sowerby, 1840)
Leptochiton cimicoides (Monterosato, 1879)

POLYPLACOPHORA Gray, 1821

ACANTHOCHITONIDAE Simroth, 1894
Acanthochitona crinita (Pennant, 1777)

GASTROPODA Cuvier, 1795

FISSURELLIDAE Fleming, 1822
Diodora graeca (Linnaeus, 1758)
Emarginula huzardii Payraudeau, 1826
Emarginula tenera Locard, 1891

ANATOMIDAE McLean, 1989
Anatoma micalii Geiger, 2012

SCISSURELLIDAE Gray, 1847
Scissurella costata D'Orbigny, 1824
Sinezona cingulata (O.G. Costa, 1861) (Figs. 6-10)
Sinezona semicostata Burnay et Rolán, 1990 (Fig. 10)

HALIOTIDAE Rafinesque, 1815
Haliotis tuberculata tuberculata Linnaeus, 1758

TROCHIDAE Rafinesque, 1815
Gibbula guttadauri (Philippi, 1836)
Gibbula turbinoides (Deshayes, 1835)
Jujubinus striatus striatus (Linnaeus, 1758)
Clanculus cruciatus (Linnaeus, 1758)

CALLIOSTOMATIDAE Thiele, 1924 (1847)
Calliostoma sp.
Calliostoma conulus (Linnaeus, 1758)
Calliostoma laugieri (Payraudeau, 1826)

SKENEIDAE Clark W., 1851
Dikoleps nitens (Philippi, 1844)
Dikoleps umbilicostriata (Gaglini, 1987)
Skenea catenoides (Monterosato, 1877)
Skeneoides exilissima (Philippi, 1844)

PHASIANELLIDAE Swainson, 1840
Tricolia deschampsi Gofas, 1993 (Fig. 11)
Tricolia landinii Bogi et Campani, 2007
Tricolia speciosa (Von Muhelfeldt, 1824)

NERITIDAE Rafinesque, 1815
Smaragdia viridis (Linnaeus, 1758)

CERITHIIDAE Fleming, 1822
Bittium lacteum (Philippi, 1836)
Bittium latreillii (Payraudeau, 1826)
Bittium reticulatum (da Costa, 1778)
Cerithidium submammillatum (De Rayneval et Ponzi, 1854)
Cerithium renovatum Monterosato, 1884
Cerithium vulgatum vulgatum Bruguiere, 1792

PLANAXIDAE Gray, 1850
Fossarus ambiguus (Linnaeus, 1758)

TURRITELLIDAE Lovén, 1847
Turritella turbona Monterosato, 1887

TRIPHORIDAE J. E. Gray, 1847
Marshallora sp.
Monophorus thiriotae Bouchet, 1985
Similiphora similior (Bouchet et Guillemot, 1978)
Metaxia metaxa (Delle Chiaie, 1828)

CERITHIOPSIDAE H. Adams et A. Adams, 1853
Krachia tiara (Monterosato, 1874)
Cerithiopsis micalii (Cecalupo et Villari, 1997)
Cerithiopsis minima (Brusina, 1865)
Cerithiopsis pulchresculpta Cachia, Mifsud et Sammut, 2004
Cerithiopsis scalaris Locard,1891
Cerithiopsis sp.
Cerithiopsis tubercularis (Montagu, 1803)

EPITONIIDAE Berry, 1910 (1812)
Epitonium algerianum (Weinkauff, 1866)

EULIMIDAE Philippi, 1853
Melanella boscii (Payraudeau, 1826)
Melanella polita (Linnaeus, 1758)
Parvioris ibizenca (Nordsiek, 1968)
Vitreolina curva (Monterosato, 1874)
Vitreolina incurva (Bucquoy, Dautzenberg et Dollfus, 1883)
Vitreolina cfr *incurva*
Vitreolina perminima (Jeffreys, 1883)
Vitreolina philippi (de Rayneval & Ponzi, 1854)
Vitreolina sp.
Nanobalcis nana (Monterosato, 1878)
Curveulima devians (Monterosato, 1884)

CINGULOPSIDAE Fretter et Patil, 1958
Eatonina ochroleuca (Brusina, 1869)
Eatonina pumila (Monterosato, 1884)

RISSOINIDAE Stimpson, 1865
Rissoina bruguieri (Payraudeau, 1826)

RISSOIDAE Gray, 1847
Rissoa similis Scacchi, 1836
Alvania cancellata (da Costa, 1778)
Alvania cimex (Linnaeus, 1758)
Alvania clathrella L. Seguenza, 1903
Alvania discors (T. Allan, 1818)
Alvania geryonia (Nardo, 1847)
Alvania hirta Monterosato, 1884
Alvania hispidula (Monterosato, 1884)
Alvania lanciae (Calcara, 1845)
Alvania lineata Risso, 1826

Alvania rudis (Philippi, 1844)
Alvania scabra (Philippi, 1844)
Alvania sp.
Alvania spinosa (Monterosato, 1890)
Alvania subcrenulata (Bucquoy, Dautzenberg et Dollfus, 1884)
Alvania weinkauffi jacobusi Oliverio, Amati et Nofroni, 1986
Crisilla beniamina (Monterosato, 1884)
Peringiella elegans (Locard, 1891)
Pusillina inconspicua (Alder, 1844)
Pusillina lineolata (Michaud, 1832)
Pusillina marginata (Michaud, 1830)
Setia amabilis (Locard, 1886)
Setia ambigua (Brugnone, 1873) (Fig. 12)
Setia homerica Romani & Scuderi, 2015
Setia maculata (Monterosato, 1869)
Setia cfr *turriculata* Monterosato, 1884
Setia turriculata Monterosato, 1884
Setia sp. (Fig. 13)

ANABATHRIDAE Keen, 1971
Pisinna glabrata (Von Muehlfeld, 1824)

BARLEEIIDAE J.E. Gray, 1857
Barleeia unifasciata (Montagu, 1803)

CAECIDAE Gray, 1850
Caecum armoricum de Folin, 1869
Caecum auriculatum de Folin, 1868
Caecum clarkii Carpenter, 1859
Caecum subannulatum de Folin, 1870
Caecum trachea (Montagu, 1803)

VERMETIDAE Rafinesque, 1815
Thylaeodus semisurrectus (Bivona-Bernardi, 1832)
Dendropoma cristatum (Biondi, 1859)

CALYPTRAEIDAE Lamarck, 1809
Crepidula aculeata (Gmelin, 1791)
Calyptraea chinensis (Linnaeus, 1758)

CYPRAEIDAE Rafinesque, 1815
Luria lurida (Linnaeus, 1758)
Naria spurca spurca (Linnaeus, 1758)

NATICIDAE Guilding, 1834
Notocochlis dillwynii (Payraudeau, 1826)
Euspira guillemini (Payraudeau, 1826)
Natica sp.

ATLANTIDAE Rang, 1829
Protatlanta souleyeti (E.A. Smith, 1888)
Atlanta brunnea J.E. Gray, 1850 (Fig. 14)
Atlanta helicinoidea J.E. Gray, 1850 (Fig. 15)
Atlanta lesuerii J.E. Gray, 1850
Atlanta peronii Lesueur, 1817
Oxygyrus inflatus Benson, 1835

MURICIDAE Rafinesque, 1815
Hexaplex (*Truncularìopsis*) *trunculus trunculus* (Linnaeus, 1758)
Ocenebra edwardsii (Payraudeau, 1826)
Ocinebrina aciculata (Lamarck, 1822)
Muricopsis (*Muricopsis*) *cristata* (Brocchi, 1814)
Coralliophila meyendorffii (Calcara, 1845)

GRANULINIDAE Boyer, 2017
Granulina marginata (Bivona, 1832)

CYSTISCIDAE Stimpson, 1865
Gibberula cristinae Tisselli, Agamennone & Giunchi 2009
Gibberula cfr *cristinae*
Gibberula philippi (Monterosato, 1878)
Gibberula recondita Monterosato, 1844
Gibberula sp.

MITRIDAE Swainson, 1829
Episcomitra cornicula (Linnaeus, 1758)

COSTELLARIIDAE MacDonald, 1860
Pusia savignyi (Payraudeau, 1826)
Pusia tricolor (Gmelin, 1791)

BUCCINIDAE Rafinesque, 1815
Euthria cornea Linnaeus, 1758
Chauvetia affinis (Monterosato, 1889)
Chauvetia brunnea (Donovan, 1804)
Chauvetia lefebvrii (Maravigna, 1840)
Chauvetia mamillata (Risso, 1826)
Chauvetia recondita (Brugnone, 1873)
Chauvetia turritellata (Deshayes, 1835)
Chauvetia ventrosa Nordsieck, 1976
Enginella leucozona (Philippi, 1844)
Aplus scaber (Locard, 1891)

COLUBRARIIDAE Dall, 1904
Cumia reticulata (Blainville, 1829)

NASSARIIDAE Iredale, 1916 (1835)
Tritia cuvierii (Payraudeau, 1826)

COLUMBELLIDAE Swainson, 1840
Columbella rustica (Linnaeus, 1758)
Mitrella coccinea (Philippi, 1836)
Mitrella minor (Scacchi, 1836)
Mitrella scripta (Linnaeus, 1758)
Mitrella svelta Kobelt, 1889

FASCIOLARIIDAE Gray, 1853
Fusinus dimassai Buzzurro et Russo, 2007

MITROMORPHIDAE Casey, 1904
Mitromorpha (*Mitrolumna*) *columbellaria* (Scacchi, 1836)
Mitromorpha (Mitrolumna) *karpathensis* (Nordsieck, 1969)

CLATHURELLIDAE H. Adams et A. Adams, 1858
Clathromangelia granum (Philippi, 1844)

CONIDAE Fleming, 1822
Conus ventricosus Gmelin, 1791

RAPHITOMIDAE Bellardi, 1875
Raphitoma contigua (Monterosato, 1884)
Raphitoma cfr *echinata*
Raphitoma laviae (Philippi, 1844)
Raphitoma leufroyi (Michaud, 1828)
Raphitoma linearis (Montagu, 1803)

MANGELIIDAE P. Fischer, 1883
Mangelia multilineolata (Deshayes, 1835)
Mangelia striolata Risso, 1826
Mangelia taeniata (Deshayes, 1835)
Mangelia unifasciata (Deshayes, 1835)
Mangelia vauquelini (Payraudeau, 1826)

RISSOELLIDAE Gray, 1850
Rissoella diaphana (Alder, 1848)
Rissoella globularis (Forbes et Hanley, 1853)
Rissoella opalina (Jeffreys, 1848)

OMALOGYRIDAE G.O. Sars, 1878
Ammonicera fischeriana (Monterosato, 1869)
Ammonicera nodulosa Oliver et Rolàn 2015 (Fig. 16)
Ammonicera rota (Forbes et Hanley, 1850) (Fig. 17)
Omalogyra simplex (Costa OG, 1861)

PYRAMIDELLIDAE J.E. Gray, 1840
Brachystomia carrozzai (van Aartsen, 1987)
Brachystomia eulimoides (Hanley, 1844)
Odostomia kromi van Aartsen, Menkhorst et Gittenberger, 1984
Odostomia lukisii Jeffreys, 1859
Odostomia sp.
Odostomia striolata Forbes et Hanley, 1850
Megastomia conoidea (Brocchi, 1814)
Ondina sp.
Parthenina clathrata (Jeffreys, 1848)
Parthenina decussata (Montagu, 1803)
Parthenina emaciata (Brusina, 1866)
Parthenina interstincta (Adams J., 1797)
Parthenina monozona (Brusina, 1869)
Odostomella doliolum (Philippi, 1844)
Turbonilla hamata Nordsieck, 1972
Turbonilla lactea (Linnaeus, 1758)
Turbonilla multilirata (Monterosato, 1875)
Turbonilla obliquata (Philippi, 1844)
Turbonilla pumila Seguenza G., 1876
Turbonilla pusilla (Philippi, 1844)
Dunkeria jeffreysi (Jeffreys, 1848)
Pyrgiscus rufus (Philippi, 1836)
Pyrgostylus striatulus (Linnaeus, 1758)
Eulimella acicula (Philippi, 1836)

MURCHISONELLIDAE Casey, 1904
Ebala nitidissima (Montagu, 1803)
Ebala pointeli (de Folin, 1868)

BULLIDAE Gray, 1827
Bulla striata Bruguiere, 1792

RETUSIDAE Thiele, 1925
Retusa mammillata (Philippi, 1836)
Retusa truncatula (Bruguiere, 1792)
Retusa laevisculpta (Granata-Grillo, 1877) (Fig. 18)
Pyrunculus hoernesii (Weinkauff, 1866) (Fig. 19)

HAMINOEIDAE Pilsbry, 1895
Haminoea sp.
Atys macandrewii E. A.Smith, 1872
Weinkauffia turgidula (Forbes, 1844)

PHILINIDAE Gray, 1850 (1815)
Philine catena (Montagu, 1803)

CAVOLINIIDAE Gray, 1850 (1815)
Cavolinia inflexa (Lesueur, 1813)

CLIIDAE Jeffreys, 1869
Clio pyramidata Linnaeus, 1767

CRESEIDAE Rampal, 1973
Creseis clava (Rang, 1828)
Styliola subula (Quoy et Gaimard, 1827)

LIMACINIDAE Gray, 1840
Limacina (*Munthea*) *trochiformis* (D'Orbigny, 1835)
Heliconoides inflatus (d'Orbigny, 1835)

PERACLIDAE Tesch, 1913
Peracle diversa (Monterosato, 1875)
Peracle reticulata (D'Orbigny, 1835)

OXYNOIDAE Stoliczka, 1868 (1847)
Lobiger serradifalci (Calcara, 1840)

VOLVATELLIDAE Pilsbry, 1895
Ascobulla fragilis (Jeffreys, 1856)

PLEUROBRANCHIDAE
Berthella cfr *aurantiaca* (Risso, 1818)

APLYSIIDAE Lamarck, 1809
Aplysia (*Pruvotaplysia*) *parvula* Mörch, 1863 (Fig. 20)
Petalifera petalifera (Rang, 1828) (Fig. 21)

SIPHONARIIDAE Gray, 1827
Williamia gussonii (Costa O.G., 1829)

ARCIDAE Lamarck, 1809
Arca noae Linnaeus, 1758
Asperarca secreta La Perna, 1998

BIVALVIA Linnaeus, 1758

NOETIIDAE Stewart, 1930
Striarca lactea (Linnaeus, 1758)

MYTILIDAE Rafinesque, 1815
Mytilaster lineatus (Gmelin, 1791)
Musculus costulatus (Risso, 1826)
Rhomboidella prideauxi (Leach, 1815)
Lithophaga lithophaga (Linnaeus, 1758)
Dacrydium hyalinum Monterosato, 1875
Modiolula phaseolina (Philippi, 1844)

PINNIDAE Leach, 1819
Pinna sp.

PTERIIDAE Gray, 1847 (1820)
Pinctada imbricata radiata (Leach, 1814)

PECTINIDAE Rafinesque, 1815
Flexopecten hyalinus (Poli, 1795)
Aequipecten sp.
Palliolum incomparabile (Risso, 1826)

LIMIDAE Rafinesque, 1815
Lima lima (Linnaeus, 1758)
Limaria hians (Gmelin, 1791)

LUCINIDAE Fleming, 1828
Ctena decussata (Costa O.G., 1829)

CHAMIDAE Lamarck, 1809
Chama gryphoides Linnaeus, 1758

LASAEIDAE Gray, 1842
Lasaea adansoni (Gmelin, 1791)

MONTACUTIDAE W. Clark, 1855
Epilepton cfr *clarkiae* (W. Clark, 1852)

CARDITIDAE Férussac, 1822
Cardita calyculata (Linnaeus, 1758)
Centrocardita aculeata (Poli, 1795)
Glans trapezia (Linnaeus, 1767)

CARDIIDAE Lamarck, 1809
Parvicardium scriptum (Bucquoy, Dautzenberg et Dollfus, 1892)
Papillicardium papillosum (Poli, 1791)

TELLINIDAE Blainville, 1814
Arcopella balaustina (Linnaeus, 1758)

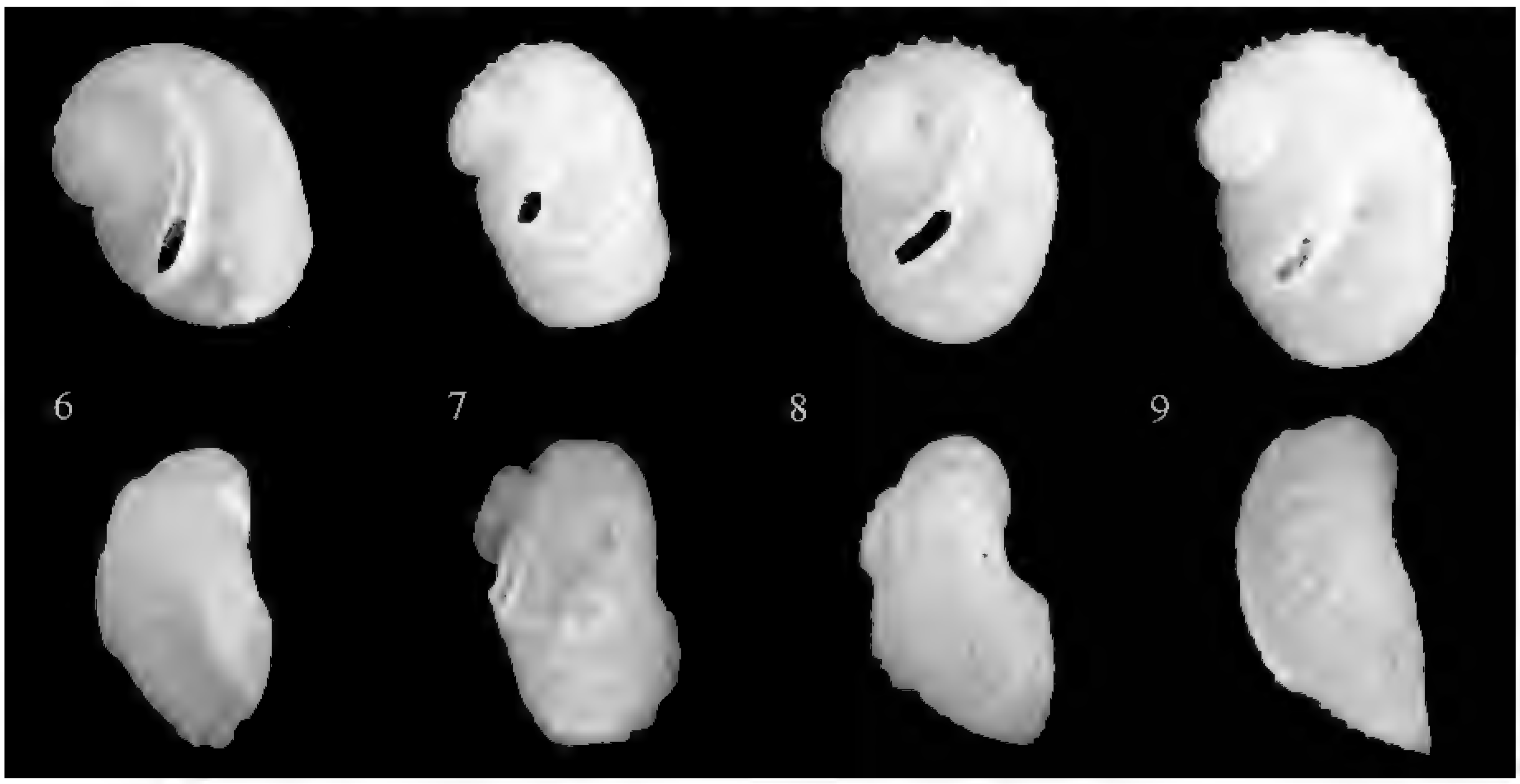
VENERIDAE Rafinesque, 1815
Gouldia minima (Montagu, 1803)
Irus irus (Linnaeus, 1758)
Lajonkairia lajonkairii (Payraudeau, 1826)

HIATELLIDAE Gray, 1824
Hiatella arctica (Linnaeus, 1767)

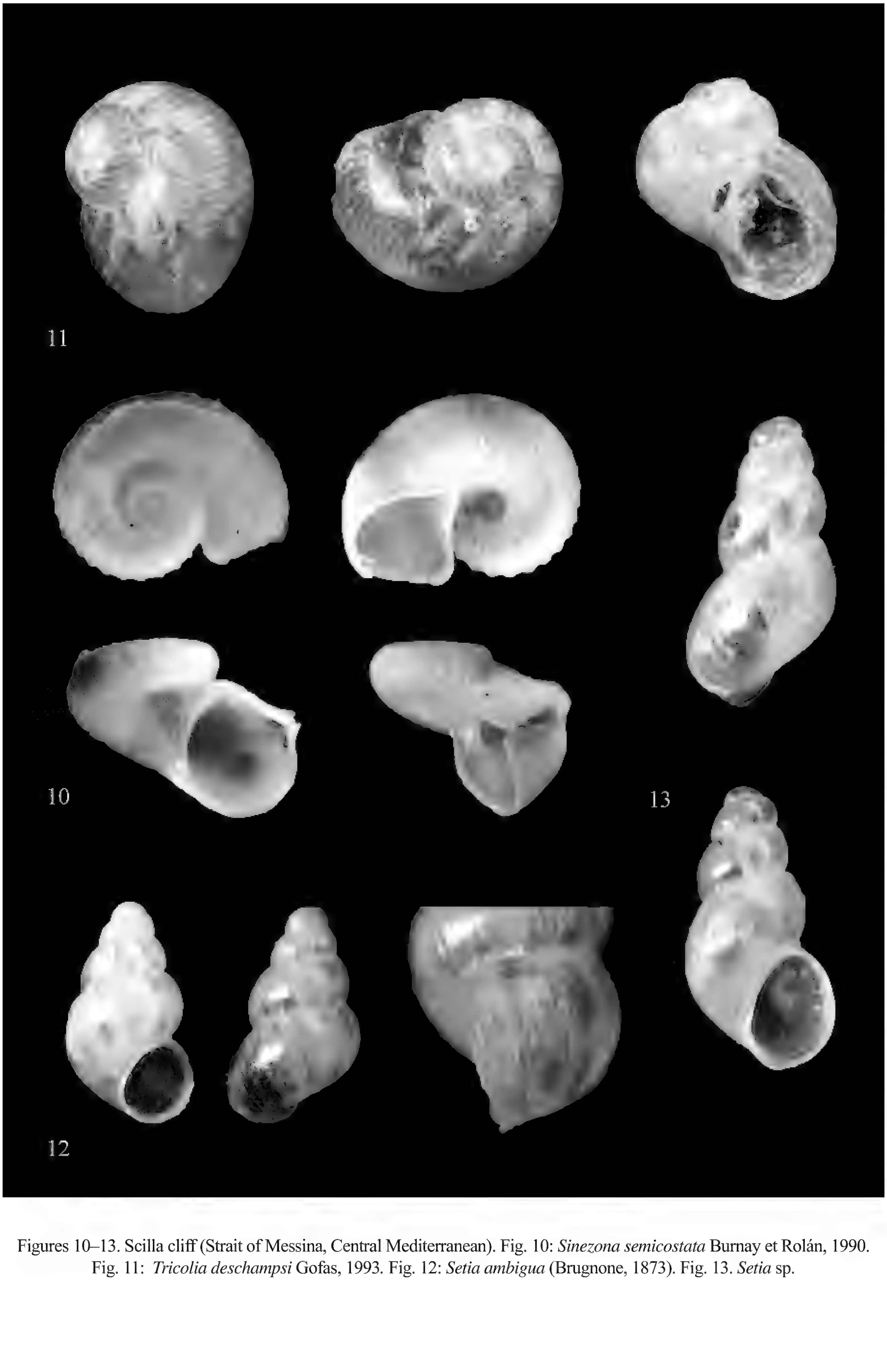
SCAPHOPODA Bronn, 1862

DENTALIIDAE Children, 1834
Antalis sp.

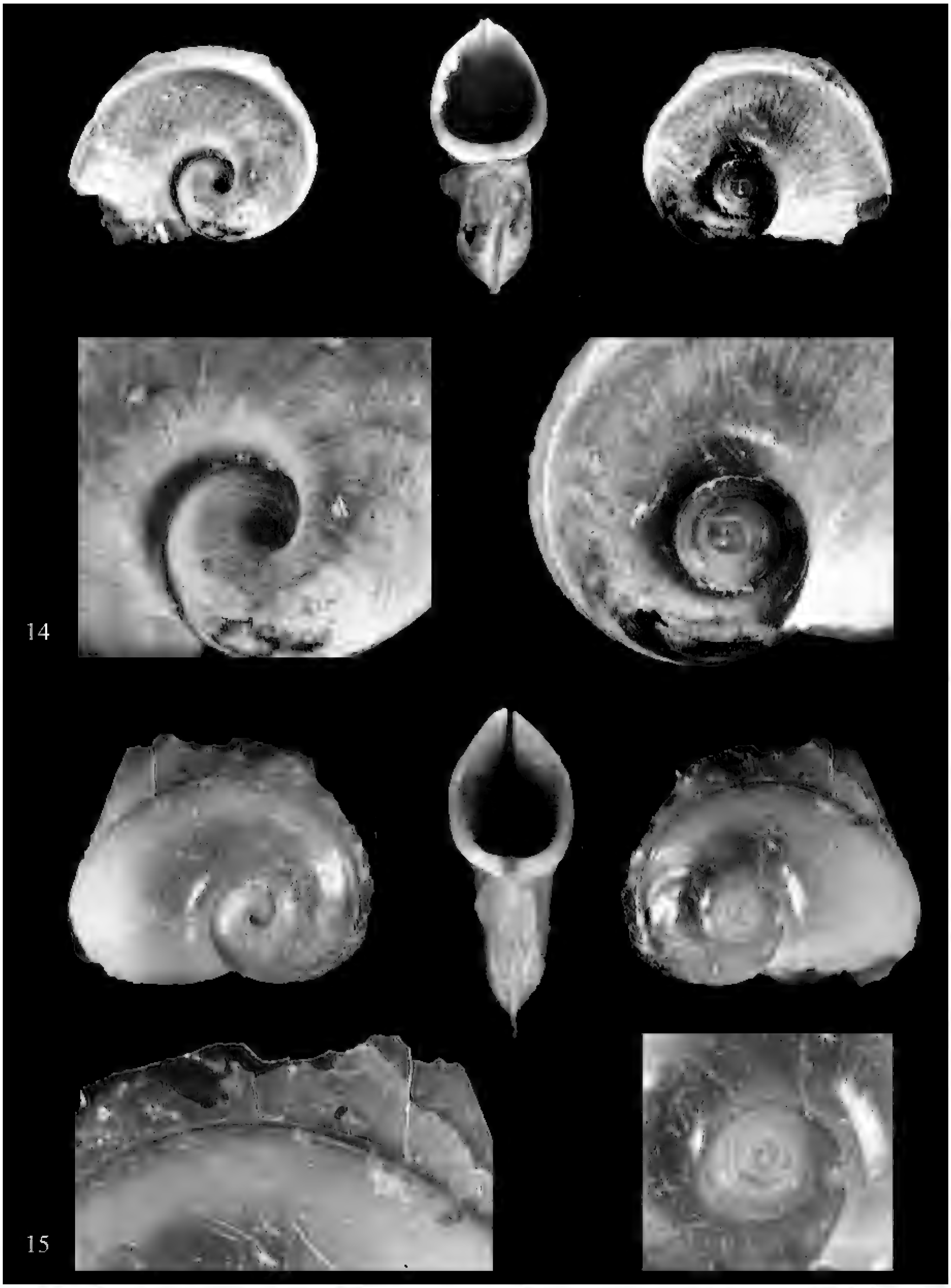
Table 1. The mollusc from the photophilic zone of Scilla cliff (Strait of Messina, Central Mediterranean).



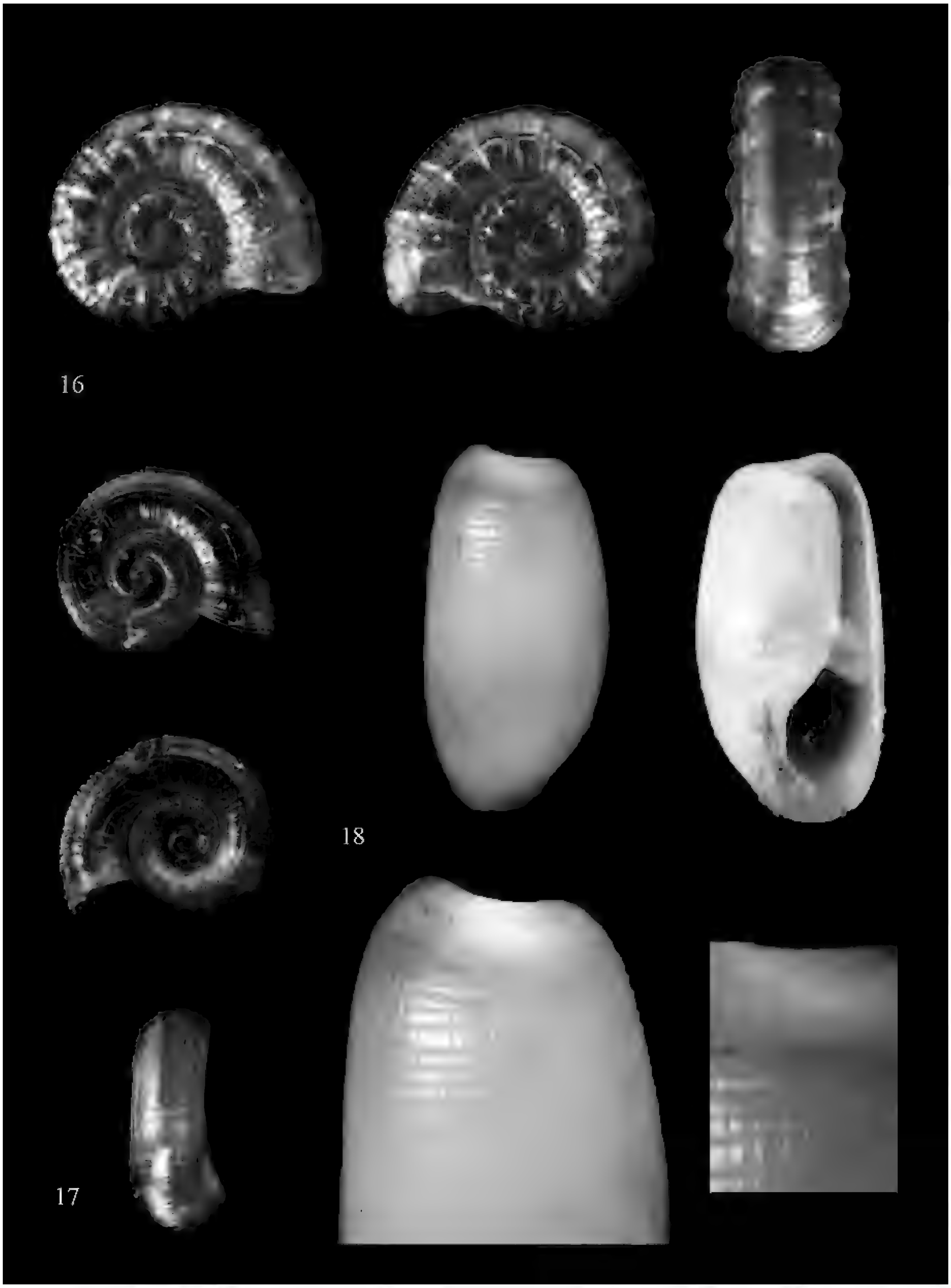
Figures 6–9. Scilla cliff (Strait of Messina, Central Mediterranean): *Sinezona cingulata* (O.G. Costa, 1861).



Figures 10–13. Scilla cliff (Strait of Messina, Central Mediterranean). Fig. 10: *Sinezona semicostata* Burnay et Rolán, 1990. Fig. 11: *Tricolia deschampsi* Gofas, 1993. Fig. 12: *Setia ambigua* (Brugnone, 1873). Fig. 13. *Setia* sp.



Figures 14, 15. Scilla cliff (Strait of Messina, Central Mediterranean).
Fig. 14: *Atlanta brunnea* J.E. Gray, 1850. Fig. 15: *Atlanta helicinoidea* J.E. Gray, 1850.



Figures 16–18. Scilla cliff (Strait of Messina, Central Mediterranean). Fig. 16: *Ammonicera nodulosa* Oliver et Rolàn 2015. Fig. 17: *Ammonicera rota* (Forbes et Hanley, 1850). Fig. 18: *Retusa laevisculpta* (Granata-Grillo, 1877).

Figures 19–21. Scilla cliff (Strait of Messina, Central Mediterranean). Figure 19. *Pyrunculus hoernesii* (Weinkauff, 1866). Fig. 20: *Aplysia* (*P.*) *parvula* Mörch, 1863. The image of a living specimen, shown for comparison, was extracted from www.seaslugforum.net/find/aplyparv). Fig. 21: *Petalifera petalifera* (Rang, 1828).

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Biodiversity Journal, 2018, 9 (3): 271–276 DOI: 10.31396/Biodiv.Jour.2018.9.3.271.276

New faunistic data for the Sicilian Aracnofauna (Arachnida Araneae)

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ABSTRACT New spiders (Arachnida Araneae) from Sicily (Italy) are reported in this paper. Particularly, one familia, eight genera, and thirteen new species are examined. Additional biological and taxonomic notes are also provided.

KEY WORDS Araneae; new data; first records; Sicily.

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INTRODUCTION

In the first article of one of the two authors (Dentici, 2017), two new species were presented for Sicily and the number of those known for Sicily rose to 405. To date, the World Spider Catalog (2018), after only one year, reports 418 known spiders.

During the sampling of the authors on the territory, which took place between the end of 2017 and half of 2018 and it is not distributed in a homogeneous way, some novelties have been found in Sicily. In fact, this work reports 1 familia, 7 genera, and 13 new species for Sicily, raising the number of spiders known to 431 species divided into 194 generates and 44 families.

These data are helping and encourage us to continue our research on our territory, sure that new data yet to be discovered are many on the Sicilian aracnofauna.

MATERIAL AND METHODS

All samples were collected on sight on plants, under the rocks or in their web. Some samples were photographed in nature with a Canon EOS 7D Mark II with a EF100mm Macro with 20 mm extension rings and 1.4 canon multiplier (F.C. Amata).

All the samples, taken in laboratory, were treated with ethyl acetate, observed with binoculars and photographed with a Nikon d90 reflex and a macro lens of 100 mm for identification by Dentici Antonino. The specimens were stored in centrifuge tubes of different sizes, depending on the size of the sample, and were fixed in 75% ethanol.

The samples are stored in the collection of one author (A. Dentici) and the “legit” is indicated for each sample. Each locality and / or collection site is in the original language (Italian).

The classification, taxonomic order, nomenclatural arrangement, and presence in the Sicilian territory follow Roberts (1995), Trotta (2004), Pantini & Isaia (2018), and World Spider Catalog (2018). Other sources have also been used for the correct identification and are, when used, signed in the species remarks.

For each species literature, chorotype and distribution are indicated.

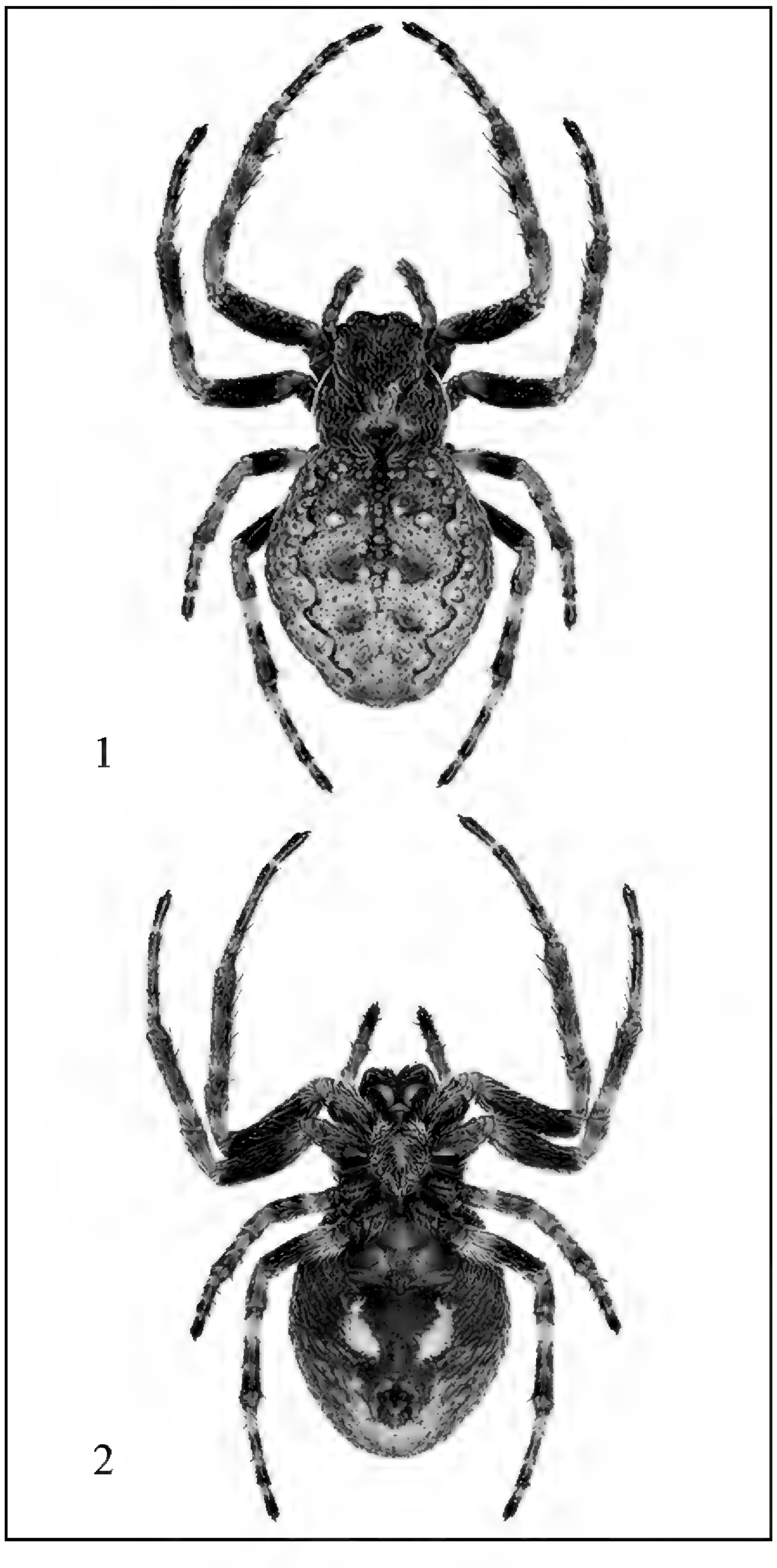
RESULTS

Systematics

Ordo ARANEAE Clerck, 1757
Familia ARANEIDAE Clerck,1757
Genus *Nuctenea* Simon, 1864

Nuctenea umbratica (Clerck, 1757)

EXAMINED MATERIAL. Sicily (Italy), Troina (Enna), 37°49'49.1" N 14°34'08.2" E, 20.I.2018, 1 female, legit F.C. Amata.



Figures 1, 2. *Nuctenea umbratica* female dorsal (Fig. 1) and ventral (Fig. 2) view (photos by F.C. Amata).

DISTRIBUTION. Europe to Azerbaijan.

REMARKS. New genus and new species for Sicily. The sample was found on its web, built in a beechwood near the lake Ancipa, which occupied the center, during the evening hours.

Familia AMAUROBIIDAE Thorell, 1870
Genus *Amaurobius* C.L. Koch, 1837

Amaurobius erberi (Keyserling, 1863)

EXAMINED MATERIAL. Sicily (Italy),Troina (Enna), 37°32'05.3" N 14°51'57.5" E, 20.I.2018, 1 female and 1 male, legit F.C. Amata.

DISTRIBUTION. Europe, Canary Islands.

REMARKS. New species for Sicily. The samples were found under a rock in a rural area, bordered by a highway. Other specimens have been studied, in the same period, in Palermo and province, attributable to the species of *A. erberi*, but immature to give a certain identification.

Familia GNAPHOSIDAE Pocock, 1898
Genus *Sethaphis* Simon, 1893

Setaphis parvula (Lucas, 1846)

EXAMINED MATERIAL. Sicily (Italy), Palermo, Monreale: Caculla, 38°03'01.3"N 13°14'42.2"E, 02.VI.2018, 1 male, legit A. Dentici.

DISTRIBUTION. Mediterranean.

REMARKS. New genus and new species for Sicily. The sample was found while wandering on a dirt road, near Sant'Elia River, at night.

This species is present on Italian territory only in Sardinia (Pantini et al., 2013) and now also in Sicily.

Familia LYCOSIDAE Sundevall, 1833
Genus *Aulonia* C.L. Kock, 1847

Aulonia albimana (Walckenaer,1805)

EXAMINED MATERIAL. Sicily (Italy), Palermo, 26.III.2018, 1 male and 1 female, legit A. Dentici.

DISTRIBUTION. Europe, Turkey, Caucasus, Russia to Turkmenistan.

REMARKS. New genus and new species for Sicily. Both specimens were sampled in a small green area on the outskirts of the city, in an anthropized area. The specimens were found under the foliage of some *Eucalyptus* trees.

Genus *Trabea* Simon, 1876

Trabea paradoxa Simon, 1876

EXAMINED MATERIAL. Sicily (Italy), Troina (Enna), 15.III.2018, 1 juvenille female, legit Franco Ciro Amata; Sicily, Palermo, Monreale: Caculla, 38°03'01.3"N 13°14'42.2"E, 19.V.2018, 1 male, legit A. Dentici.

DISTRIBUTION. Southern Europe, Turkey.

REMARKS. New genus and new species for Sicily. These two specimens were collected both during the evening hours, wandering in gardens of private homes in the countryside area.

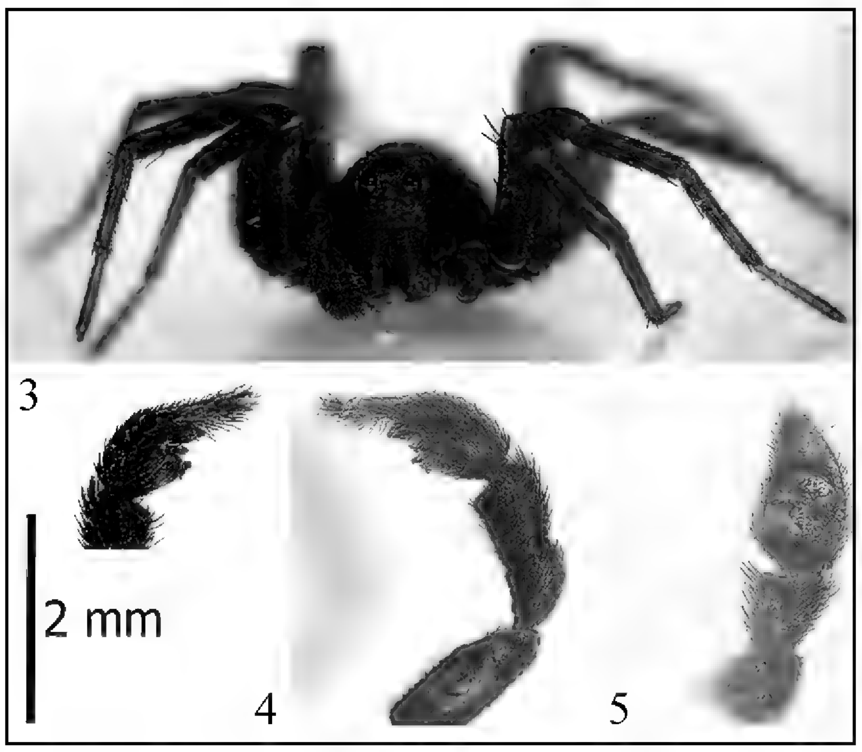
Familia LYNIPHIIDAE Blackwall, 1859
Genus *Lyniphia* Latreille, 1804

Lyniphia tenuipalpis Simon, 1884

EXAMINED MATERIAL. Sicily (Italy), Palermo, Pioppo, Bosco di Casaboli, 38°04'01.0"N 13°13'42.9"E, 22.X.2017, 1 female, legit A. Dentici (Natural Science Museum E. Caffi of Bergamo collection).

DISTRIBUTION. Europe to Central Asia, Algeria.

REMARKS. New species for Sicily. The specimen was collected on its web, built among the brambles.



Figures 3–5. *Aulonia albimana* male frontal view (Fig. 3), palp lateral (Fig. 4), and frontal view (Fig. 5).

Familia MITURGIDAE Simon, 1886
Genus *Zora* C.L. Koch, 1847

Zora manicata Simon, 1878

EXAMINED MATERIAL. Sicily (Italy), Troina (Enna), 37° 48'19.8" N 14° 38'47.5" E, 12.II.2018, 2 female, legit F.C. Amata.

DISTRIBUTION. Europe, Israel, Iran.

REMARKS. New genus and new species for Sicily. The specimens were sampled in a tree-lined area along a state road, which runs through a rural area. They were found under rocks. The sample was identified through description of Levy (2003).

Familia SEGESTRIIDAE Simon, 1893
Genus *Segestria* Latreille, 1804

Segestria bavarica C.L. Koch, 1843

EXAMINED MATERIAL. Sicily (Italy), Palermo, Monte Pellegrino, 11.XI.2017, 1 female, legit A. Dentici.

DISTRIBUTION. Europe to Azerbaijan.

REMARKS. New species for Sicily. The sample was found exiting its tubular web, during the night. The den had been built inside a hole in a *Eucalyptus*.

In the same area, *S. florentina* (Rossi, 1790) specimens were observed. In one case, the two species were observed on the cavities of the same tree, in which the *S. bavarica* occupied the highest and *S. florentina* the lowest ones.

Familia THERIDIIDAE Sundevall, 1833
Genus *Episinus* Walckenaer, 1809

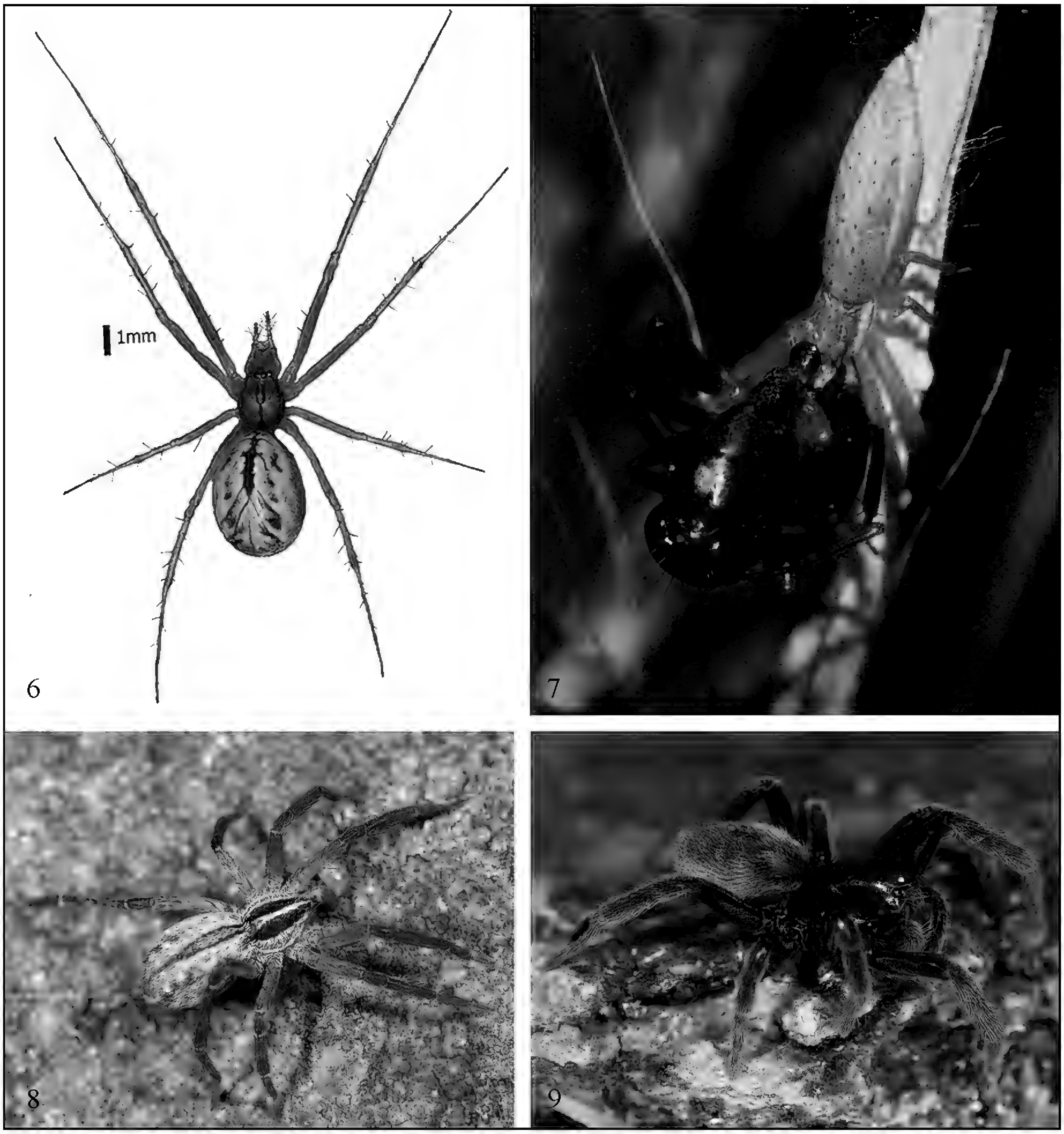


Figure 6. *Lyniphia tenuipalpis* female (photo by A. Dentici). Figure 7. *Monaese paradoxus* preying on *Camponotus barbaricus* Emery, 1904 (photo by A. Dentici). Figure 8. *Zora manicata* female (photo by F.C. Amata). Figure 9. *Titanoeca tristis* (photo by F.C. Amata).

Episinus algiricus Lucas, 1846

EXAMINED MATERIAL. Sicily (Italy), Palermo, Parco della Favorita, 38°09’46.0”N 13°20’18.9”E, 2 female and 3 male, legit A. Dentici; Sicily (Italy), Palermo, Monte Pellegrino, 38°09’51.3”N 13°20’52.3”E, 24.VI.2018, 1 female, legit A. Dentici.

DISTRIBUTION. Portugal, Spain, France, Italy, Northwest Africa, Malta (?).

REMARKS. The specimens were sampled on their webs, during the evening hours. The webs were built on a chain-link fence that runs along a path inside the reserve. The canvases were not far from each other. New species for Sicily. This new

data for the Sicilian territory supports the reports about the presence of *E. algiricus* on the Maltese Archipelago (Dentici, 2018).

Genus *Rhomphaea* L.Koch,1872

Rhomphaea rostrata (Simon, 1873)

Examined material. Sicily (Italy), Palermo, Monreale: Caculla, 38°03'01.3"N 13°14'42.2"E, 10.VI.2018, 1 male, legit A. Dentici.

Distribution. Canary Islands, Portugal, Spain, France, Italy, Bosnia and Herzegovina, Croatia, Greece.

Remarks. New genus and new species for Sicily. The specimen was sampled on a lemon tree in a private garden, near Sant'Elia River, during the night.

Familia THOMISIDAE Sundevall, 1833
Genus *Monaeses* Thorell, 1869

Monaeses paradoxus (Lucas, 1846)

Examined material. Sicily (Italy), Palermo, Monte Pellegrino, 38°08'56.7"N 13°21'28.1"E, 16.IV.2016, 1 female, legit A. Dentici; Sicily, Palermo, Aspra, 38° 08'59"N 13°29'24"E, 17.IV.2018, 1 female, legit R. Viviano.

Distribution. Europe to Iran, Africa.

Remarks. New genus and new species for Sicily. The specimens were collected while standing on plants belonging to the Poaceae family, waiting for their prey. One of the two specimens was observed while he was preying on an ant *Camponotus barbaricus* Emery,1904 (Hymenoptera Formicidae).

Genus *Xysticus* C.L. Koch, 1835

Xysticus audax (Schrank, 1803)

Examined material. Sicily (Italy), Catania, Mareneve (Etna), 37°45'36"N 15°04'07"E, 26.V.2018, legit R. Viviano.

Distribution. Europe, Turkey, Caucasus, Kazakhstan, Russia (Europe to Far East), Japan.

Remarks. The sample was found under a rock. New species for Sicily.

Familia TITAENOCIDAE Lehtinem, 1967
Genus *Titanoeca* Thorell, 1870

Titanoeca tristis L. Koch, 1872

Examined material. Sicily (Italy), Troina (Enna), 12.II.2018, 2 female, legit Franco Ciro Amata.

Distribution. Europe to Central Asia.

Remarks. New familia, new genus, and new species for Sicily. The specimens were found under rocks, in an open area, near a provincial road. Both specimens were found under the same rock.

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Biodiversity Journal, 2018, 9 (3): 277–282 DOI: 10.31396/Biodiv.Jour.2018.9.3.277.282

Pachydema lopadusanorum n. sp. (Coleoptera Melolonthidae) from Lampedusa Island (Sicily Channel, Central Mediterranean Sea, Italy)

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ABSTRACT In this paper the populations of *Pachydema* Castelnau, 1832 (Coleoptera Melolonthidae) living in Lampedusa Island (Sicily Channel, Central Mediterranean Sea, Italy), so far attributed to *P. hirticollis* (Fabricius, 1787) of North Africa, are examined. The comparison of the main morphological characters between these two populations allowed to attribute those of Lampedusa to a new species that is described in the present work. Faunistic and biological observations on these species are provided

KEY WORDS Scarabaeoidea; *Pachydema*; taxonomic; new species; North Africa; C-Mediterranean.

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INTRODUCTION

The genus *Pachydema* Laporte de Castelnau, 1832 (Coleoptera Melolonthidae) includes about 100 species distributed throughout the Canary Islands, North Africa, Oman (1 species) and the Middle East (Baraud, 1985; Lacroix, 2005; Král & Smetana, 2006). Many species of this genus are endemic, uncommon, and with a marked sexual dimorphism.

Among them, *P. hirticollis* (Fabricius, 1787), reported from Algeria, Tunisia, and Libya, is also present in Italy in Lampedusa and Pantelleria islands, Sicily Channel (Ragusa, 1887, 1893, 1907; Baraud, 1977, 1985; Arnone et al., 1995; Carpaneto & Piattella, 1995; Sparacio, 1995; Král & Smetana, 2006; Lacroix, 2007; Ballerio et al., 2010).

The comparison between the Lampedusa and the North African populations of *P. hirticollis* made it possible to highlight some peculiar morphological differences that allowed to attribute those from Lampedusa to a distinct species herein described.

ACRONYMS AND ABBREVIATIONS. Marcello Arnone collection, Palermo, Italy (CMA); Michele Bellavista collection, Palermo, Italy (CMB); Ignazio Sparacio collection, Palermo, Italy (CIS); Collection of Museum für Naturkunde der Humboldt Universität, Berlin, Germany (ZMHB); Collection of Museo Civico di Storia Naturale "Giacomo Doria", Genova, Italy (MCSNG); Collection of Museum National d'Histoire Naturelle, Paris, France (MNHN); ex/x: specimen/s. Unless otherwise stated, the collector of the beetles in the field is the owner of the collection.

RESULTS

Systematics

Ordo COLEOPTERA Linnaeus, 1758
Familia MELOLONTHIDAE Samouelle, 1819
Subfamilia MELOLONTHINAE Samouelle, 1819
Tribus TANYPROCTINI Erichson, 1847
Genus *Pachydema* Laporte de Castelnau, 1832

Pachydema lopadusanorum n. sp. (Fig. 1)

TYPE MATERIAL. Holotypus male: Lampedusa Island (Sicily, Italy), 13.V.1983 (CIS); paratypes, idem, 16 males and 1 female (CIS); idem, legit I. Sparacio, 3 males and 1 female (CMB); Lampedusa Island, Vallone Imbriacola, 19.IV.1987, leg. M. Arnone, 10 males (CIS); idem, 19.IV.1987, leg. M. Arnone, 42 males and 8 females (CA); idem, 18.II.2017, legit T. La Mantia, 2 females (CIS); Lampedusa 1902 - Horn; Lampedusa [V.1886 leg. L. Failla], 4 males and 1 female, collection E. Ragusa (CMC).

OTHER EXAMINED MATERIAL. *Pachydema hirticollis* (Fig. 2). Tunisia. Tunis - *quedenfeldti*, Monastir, Brsk. - Coll. Brenske, 1 ex (ZMHB, syntype Collection Brenske of *P. quedenfeldti* Brenske, 1889). Tunisia, Kamait, 23.IV.1882, G. e L. Doria, Museo Civico di Genova, 7 males and 3 females (MCSNG). Tunisia, 4.VI.1972, G. Fiori, Museo Genova ex coll. G. Fiori (1987), 2 females (MCSNG). Biserta, 23.IV.1994, leg. F. Tagliaferri, 8 males and 1 females (MCSNG). Capo Bon, Korbous, 15.V.1987, 3 males and 1 female (CIS); idem, 26 e 29.IV.1998, 108 males and 18 females (CIS); Sousse, 5.V.1992, 2 females (CIS).

Pachydema demoflysi Normand, 1938. Tunisia, Sbeitla, 16.V.1996, H. Pierotti, 3 males (MCSNG).

DESCRIPTION OF HOLOTYPUS. Male. Lenght 12 mm. Head, antennae, palpi, legs, pronotum, and ventral surface black in colour; elytrae red. Pubescence long and yellowish, very dense on the ventral surface.

Head with deep and dense punctures and long and yellowish pubescence. Clypeus wider than long (width clypeus/lenght clypeus = 1.9), fore margin high, slightly emarginated in the middle, with large, very dense and irregular punctures. Antennae 10-segmented (Fig. 3), club 5-segmented, shorter of the funicle; scape elongated and dilated distally, 2° segment short and roundish, shorter than the 3°; 3°–4° elongated; 5° short and transverse. Maxillary palpi with last article fusiform with pointed apex.

Pronotum convex, transverse (width pronotum/lenght pronotum = 2.1), sub-trapezoidal, maximum width at its posterior third, covered by long and yellowish pubescence, that of the fore margin is directed mainly backwards; pronotal lateral margins subrectilinear in the posterior half after narrow and straight forward; the fore margin is slightly protruding at the middle with fore angles normally shaped; the pronotal bases is widely protruding in the backwards, posterior angles little obtuse; punctures large, deep, and dense.

Scutellum triangular with slightly arched sides, and with a line of large and confluent punctures on the sides. Elytrae a little elongated, slightly rounded on the sides with maximum width at posterior third and yellowish setae on the lateral margins; punctures large and dense, confluent on disc; interstriae obsolete, the 1° is flat, hardly visible. Humeral callus visible.

Anterior tibiae tridentate, with a little basal tooth, 2° and 3° tarsomeres flat and rounded (Fig. 5). Posterior tibiae enlarged at the middle of the inferior margin and, after, strongly dilated towards the apex; posterior tarsi longer than tibiae (lenght tarsi/lenght tibiae = 1.5). First posterior tarsomere shorter than the 3° tarsomere. Claws bifid.

Pygidium pointed-rounded at apex, finely micro-reticulated with small punctures. Metathoracic wings fully developed.

Aedeagus (Fig. 9) rather long and robust, the parameres apices (in lateral view) are a little elongated and a little pointed.

VARIABILITY. The paratypes males have no substantial morphological differences compared to the holotype. Lenght 11–13.2 mm. The 1° elytral interstria is always hardly visible, often absent distally. The paratype females are bigger (lenght 14–16.5), with a more convex dorsum, wider distally, reddish-brown in colour, sometimes very dark; antennae and tarsi shorter; punctures of the pronotum large, deep and dense; elytrae smooth with punctures very small and spaced. Propygidium with small punctures on microreticulated surface; pygidium with punctures medium sized and dense.

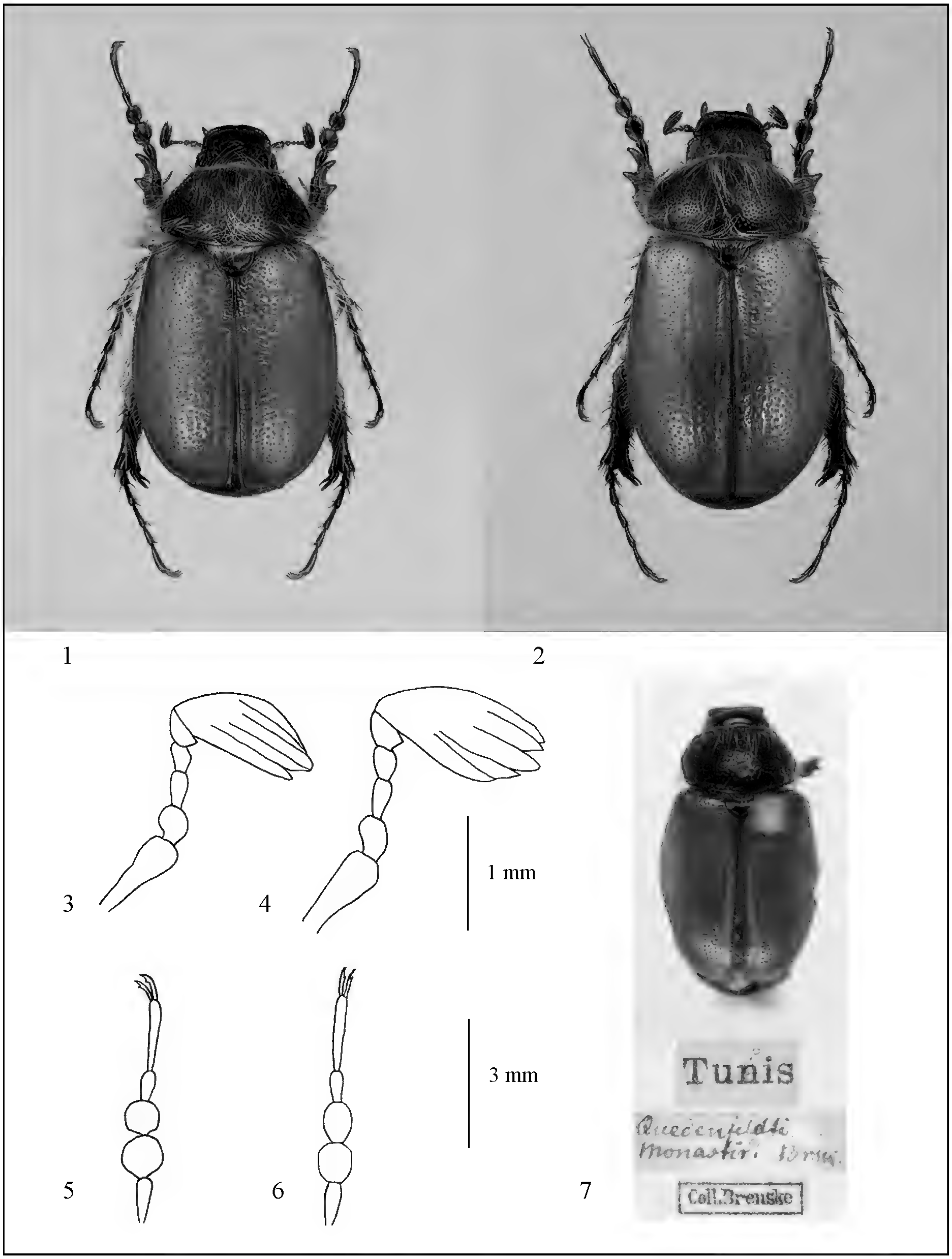

Figure 1. *Pachydema lopadusanorum* n. sp. from Lampedusa island (lenght 11.8 mm). Figure 2. *Pachydema hirticollis* from Tunisia, Capo Bon, Korbous (lenght 12.4 mm). Figure 3. Antennae of *P. lopadusanorum* n. sp. Figure 4. Antennae of *P. hirticollis*. Figure 5. Anterior tarsomeres of *P. lopadusanorum* n. sp. Figure 6. Anterior tarsomeres of *P. hirticollis*. Figure 7. Syntype of *P. quedenfeldti* (from Tunisia, Monastir).

ETYMOLOGY. Latin name of type locality: "*lopadusanorum*", that live in Lampedusa. The species is named after the people from Lampedusa island (Sicily Channel, Italy), and in particular to Vincenzo Billeci, Giuseppe Maraventano, Elena Prazzi, Francesco Sanguedolce, and Gerry Sorrentino, who fight for the conservation of nature and human values on that small patch of land surrounded by the sea.

DISTRIBUTION AND BIOLOGY. *Pachydema lopadusanorum* n. sp. is endemic to Lampedusa Island (Sicily Channel, Central Mediterranean Sea, Italy). Adults are active in spring and summer and can be found in flight or on flowers (Sparacio, 1995; Arnone et al., 1995; Ballerio et al., 2010; all sub *P. hirticollis*).

STATUS AND CONSERVATION. The few populations and restricted distribution makes *P. lopadusanorum* n. sp. as "Vulnerable", according to the Categories and Criteria of the IUCN Red List of Threatened Species (IUCN, 2017).

COMPARATIVE NOTES. *Pachydema lopadusanorum* n. sp. appears distinct morphologically from the North African populations of *P. hirticollis* as follows:

1. Body more elongated, maximum width of the elytrae towards the middle. Second segment of the antennal funicle elongated and roundish, almost as long as the 3°. Pronotum less transverse, more rounded at the sides with medium-size and spaced punctures. First elitral interstria wide, convex, clearly visible throughout the length of the elytrae. Second and third anterior tarsomeres roundish and elongated. Propygidium and pygidium of the females with bigger punctures. Aedeagus (Fig. 8) slender, the parameres apices (in lateral view) are long and pointed..................*Pachydema hirticollis*

2. Body shorter and wider, maximum width of the elytrae at the apical third. 2° segment of the antennal funicle less elongated and more roundish, shorter than the 3°. Pronotum larger and straighter on the sides, with punctures bigger and denser. 1° elitral interstria is flat, not very visible, often absent distally. Second and third anterior tarsomeres roundish. Propygidium and pygidium of the females with smaller punctures. Aedeagus (Fig. 9) shorter, the parameres apices (in lateral view) a little elongated and a little pointed...................................
..........................*Pachydema lopadusanorum* n. sp.

Pachydema hirticollis is a moderately variable species morphologically. Some different taxa are considered as synonymous of *P. hirticollis* (locus typicus: Africa Dom Vahl) and they are summarized by Baraud (1985), Král & Smetana (2006), and Lacroix (2007). They, all of North African origin, are: *P. barbara* Rambur, 1843 (locus typicus: "Côte de Barbarie"), *P. nigricans* Laporte, 1832 (locus typicus: "femelle, Barbarie, Tunis"), *P. quedenfeldti* Brenske, 1889 (locus typicus: Monastir), *P. rufipennis* Burmeister, 1855 (locus typicus: "In Algerien"), *P. spreta* Fairmaire, 1860 (locus typicus: Tunis).

One syntype of *P. quedenfeldti* (from Tunisia, Monastir; type material is made of four specimens - ZMHB) shows the pronotum with more straight sides, but all the other characters correspond to

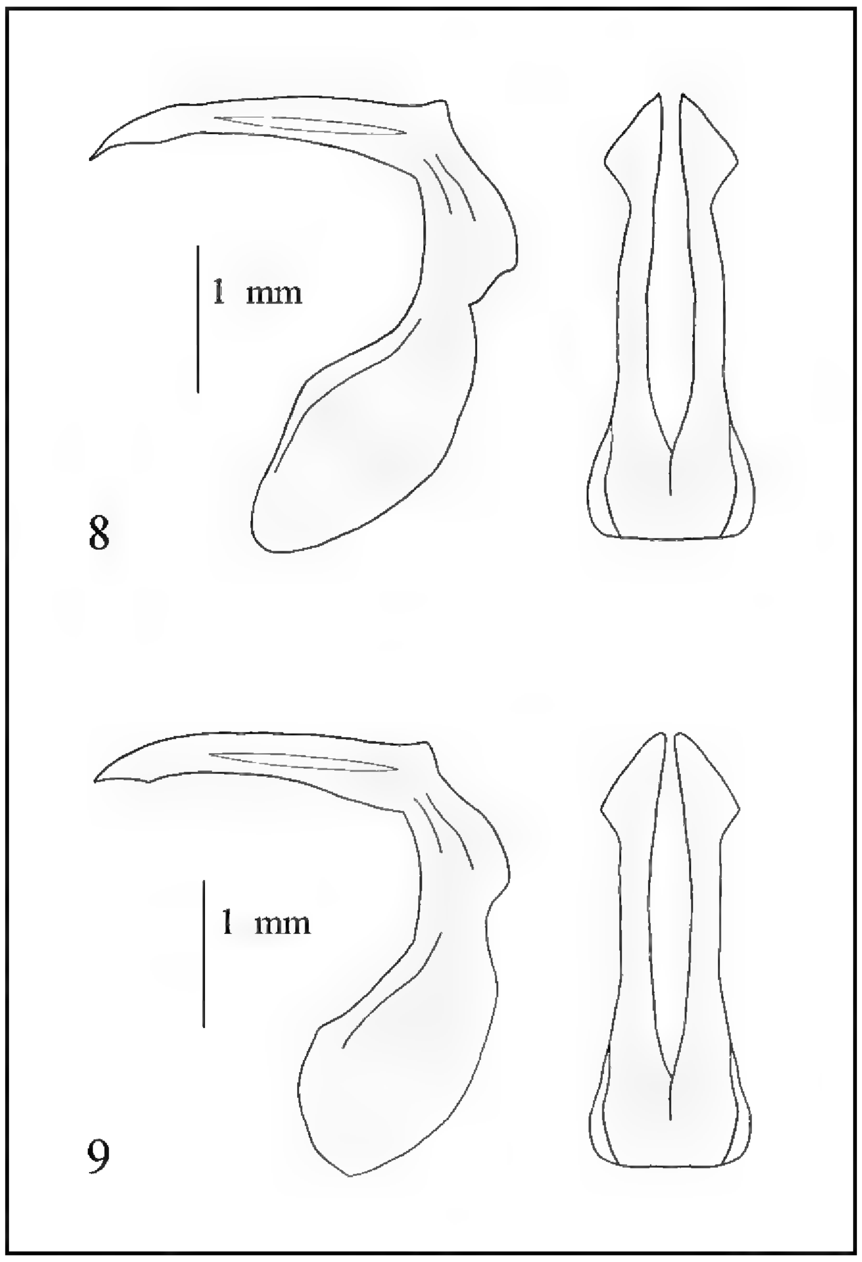

Figure 8. Aedeagus, lateral and dorsal view, of *Pachydema hirticollis*. Figure 9. Aedeagus, lateral and dorsal view, of *Pachydema lopadusanorum* n. sp.

those of other North African populations of *P. hirticollis* (Fig. 7).

Pachydema demoflysi from Tunisia is distinct from these two species due to the smaller size, the narrower clypeus, smaller punctures of pronotum, and the shape of the aedeagus (see also Baraud, 1985 and Lacroix, 2007).

Pachydema decorosa Normand, 1936 (locus typicus: Le Kef) is similar to *P. hirticollis* and is little known. It is cited by Král & Smetana (2006) and Lacroix (2007); for morphological differences see Baraud (1985).

REMARKS. *Pachydema hirticollis* occurs in Algeria, Tunisia, and Libya. For Italy, Ragusa (1887, 1893, 1907) reported the capture of a pair of *P. hirticollis* in Lampedusa by Luigi Failla Tedaldi in May 1886. The occurrence of this taxon in Lampedusa was confirmed in the following bibliography (Bertolini, 1899; Luigioni, 1929; Porta, 1932; Baraud, 1977, 1986; Du Chatenet, 1986; Carpaneto & Piattella, 1995; Sparacio, 1995; Král & Smetana, 2006; Lacroix, 2007). In particular, Gridelli (1960: Cala Madonna and Monte Parrino, IV-V.1954-1956) and Arnone et al. (1995: Cala Galera, Vallone Imbriacola, Spiaggia dei Conigli) provided several localities within Lampedusa. Arnone et al. (1995), moreover, indicated *P. hirticollis* also for Pantelleria, but this population has not been studied.

All these records from *P. hirticollis* for Lampedusa island must now refer to *P. lopadusanorum* n. sp.

For these species in Tunisia and Lampedusa, see also: http://www.entomologiitaliani.net/public/forum/phpBB3/viewtopic.php?t=29334 and http://www.entomologiitaliani.net/public/forum/phpBB3/viewtopic.php?t=43785.

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Marine molluscs from Cape Milazzo (Sicily, Italy): a baseline

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ABSTRACT An original data set of 556 benthic mollusc taxa, as a first account of Cape Milazzo local biodiversity, is provided. Qualitative differences between more or less anthropized areas have been put in evidence, and species distribution according to the main habitat typologies has been detailed. The highest biodiversity was found in the northern sites, corresponding to the Zone A of the established marine protected area. Most mollusc species under the European Economic Community (EEC) and National protection, and other ones listed as threatened, have been recorded, and are mainly associated to priority habitats as phanerogams meadows and vermitid reefs. In the meantime, the settlement of not indigenous species, mainly of tropical origin, and disease affecting threatened organisms under EEC protection, testified the vulnerability of the local ecosystem under the global change threat.

KEY WORDS Mediterranean; molluscs; marine reserves; biodiversity; threatened species.

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INTRODUCTION

The naturalistic heritage of Cape Milazzo has long been recognized and in May 2018 it lead to the establishment of a marine protected area. Scientific literature, however, is poor in information concerning the local marine biodiversity, especially on what concerns mollusc fauna, whose contribution is almost unknown. On the contrary, the fossil mollusc assemblages have been widely described (e.g., Ruggeri & Greco, 1965).

Current knowledge about the just declared marine protected area mainly regards coastal fishes assemblages, whose assessment in some priority habitats, as rocky algal reefs and *Posidonia oceanica* (L.) Delile meadows (UNEP-MAP-RAC/SPA, 2006), has been recently carried out in support of zoning proposal (La Mesa et al., 2017). Benthic fish assemblages are also known from near-shore vermetid reefs (Consoli et al., 2008). A further priority habitat of builder molluscs, *Dendropoma cristatum* (Biondi, 1859), has been studied in their genetic/biogeographic features (Templado et al., 2016). Benthic fauna from marine caves has been recently investigated by Scotti et al. (2017), which reported 37 taxa belonging to poriferans, cnidarians, annelids, and briozoans, although without mentioning molluscs. Overall, 55 species of molluscs have been reported in the past by Bombace (1969,1970) from coralligenous seafloors, while 89 species have been recently reported by D'Alessandro et al. (2016) from a wide area of the Milazzo Gulf outside the proposed protected area. Dated sporadic records (Di Natale, 1982) have concerned some introduced taxa, namely the gastropod *Cerithium scabridum* Philippi, 1848 and the bivalve *Pinctada imbricata radiata* (Leach, 1814).

The aim of this paper is to provide original data on Cape Milazzo mollusc fauna and to constitute a baseline on which future dynamics of marine biodiversity both in protected and not protected areas can be evaluated.

MATERIAL AND METHODS

Study area

Cape Milazzo, located in the north-eastern coast of Sicily (Central Mediterranean), extends northward towards the Tyrrhenian Sea for about 6 km and stretches to a maximum width of 1.5 km (Fig. 1). The coastline is characterized by high rocky cliffs with cobble pocket beaches, due to high hydrodynamism and wave exposure, especially in the northern and western promontory's sides. Steep rocky bottoms prevail, but also sand-gravel inlets and patchy distributed *Posidonia oceanica* beds are widely diffused. South-eastern coasts are submitted to a lower water circulation, mainly flowing eastward, which generates an area of sediment accumulation (Sitran et al., 2009). Close to the promontory, anthropogenic pressure is high, mainly due to the presence of oil refineries and associated marine traffic. Impacts on marine environment have been investigated by Bergamasco et al. (2014), D'Alessandro et al. (2016), Di Bella et al. (2018), but only marginally they have been involved with the promontory coastal waters.

Meanwhile, issues related to the management of the Marine Protected Area have already been addressed, for example regarding the interference with small-scale fisheries (Battaglia et al., 2017).

The proposed zonation of the reserve includes: a zone A, in which no activity other than those authorized for the purpose of scientific research would be permitted; a zone B, with less restrictive regulation, except in the sub-sector Bs where the limitations would be greater; and a zone C, in which would be forbidden only underwater fishing and some recreational sporting activities such as water skiing or jet skiing.

The zone A, at the extreme north of the Cape, is mainly characterized by relevant coralligenous formations (Bombace 1969, 1970). The almost discontinuous zone B, in the north, includes the seabed surrounding "Punta Mazza", a stretch of the east coast between Cirucco Point and Rugno Point, the Bay of S. Antonio to north-west, and a short stretch of coastline near the "Testa dell'Impiccato", southernmost. The sub-area Bs, to the north-west, includes a jagged stretch of coast with the so called West Shoal, Portella reef, and several small rocks and shoals.

Methods

A checklist of benthic mollusc species has been compiled according to WoRMS (http://www.marinespecies.org/), and updated at 2018-07-30, employing data collected in various contexts and research programs. The whole data set has been organized according to the proposal of reserve zonation, but including also some areas that should be considered of naturalistic value although not considered in the protection plan. Areas impacted by various anthropic activities have also been considered. Overall, five sites have been distinguished, as shown in figure 1:

Site 1. Area facing the industrial plants of Milazzo, the Mediterranean Refinery, and the thermoelectric power plant. Samples have been collected by diving within 10 m of depth.

Site 2. Industrial port of Milazzo. Samples have been collected by scraping iron pillars, from 3 m to 7 m depth, in September 2010. Other data have been collected by washing overall 70 dm3 of mud-sandy sediment sampled from June 2015 to June 2016.

Site 3. East coast, from the Marina of "Vaccarella" up to Cala Oliva Point. Samples collected by diving within 10 m of depth, on sandy bottom with emerging rock slabs and patch-distributed *Posidonia oceanica* meadows.

Site 4. North-eastern coast, characterized by a short stretch of sandy beach alternating with small rocky cliffs from Riva Smeralda to Cirucco point. Samples have been collected by diving within 10 m of depth, on sandy bottoms with emerging rock slabs and patch-distributed *Posidonia oceanica* meadows. Further data have been collected by dredging between 50 m and 60 m depth.

Site 5. Northern coast, corresponding to the proposed zone A (integral reserve). Samples have been manually collected from reef pools in Mazza Point (a); from remainders on fishing nets operat-

ing on mud-detrital floors, 180–200 m depth, 2 NM NE from Mazza Point (b) and similarly 2 NM NW from Gamba di Donna Point (c); by SCUBA divers on hard bottom from "Scoglio della Portella", 25–35 m depth (d) and from Cala S. Antonino, on patch distributed *Posidonia oceanica* meadows, 20 m depth.

Each record, moreover, has been contextualized in a simplified habitat typology, as follows:

PA - Photophilic Algae, on rocky cliff or cobbles, eventually trapping sand deposits.

PM - Phanerogam Meadows, mainly *Posidonia oceanica* on sandy or rocky bottoms, most rarely *Cymodocea nodosa* (Ucria) Asch. on sandy or sand-muddy bottoms.

RP - Reef Pools.

CD - Coastal Detritic and Biodetritic bottoms, including deep coralligenous formations.

SR - Supratidal Rocky reef.

Figure 1. Cape Milazzo: the monitored sites (1–6) and the sub-areas of site 5 (a–e) are indicated.

Collections of stranded pelagic species have been moreover carried out in the five sites, but also in the western coast (site 6), due to particularly favorable wind exposure.

RESULTS AND DISCUSSION

The monitoring of Cape Milazzo seafloors overall provided 556 taxa, including 9 polyplacophorans, 392 gastropods, 152 bivalves, and 4 scaphopods, whose distribution per site and habitat type is arranged in Table 1. High numbers of species were found in the harbor area (Site 2), as well as in the Riva Smeralda (Site 4), which counted 243 and 217 taxa respectively. Site 3, close to the City of Milazzo, has provided 128 species, whilst just 57 species have been reported from the seafloors facing the industrial pole (Site 1).

The northernmost area, Site 5, was the most biodiverse, counting 155 species found in the sub-area 5c, 142 species in 5b, and 139 in 5d. Only 12 species have been recorded in Cala S. Antonino (5e) occasional samplings, while the low diversity (33 species) found in 5a supported with the reef pool (RP) extreme conditions. The Littorinidae *Melarhaphe neritoides* (Linnaeus, 1758) and *Echinolittorina punctata* (Gmelin, 1791) were the only mollusc species recorded in the extreme habitat of the supratidal rocky cliff (SR). The phanerogam meadow habitat (PM) showed, as expected, the highest biodiversity (302 species), followed by the photophilc algae (PA) and coastal detritic (CD) environments, which counted almost the same number of species (259 and 267, respectively). CD shared a notable number of species with the coralligenous formations investigated in the past by Bombace (1969, 1970), which listed 55 species of gastropods and 35 of bivalves, of which only three species were lacking in the present investigation, i.e., the gastropod *Babelomurex cariniferus* (Sowerby, 1834), reported as *Coralliophila babelis* (Requien, 1848), and the bivalves *Globivenus effossa* (Philippi, 1836) and *Coralliophaga lithophagella* (Lamarck, 1819).

The most interesting species recorded in the proposed zone A was a fresh empty shell of *Haliella tyrrenica* Di Geronimo et La Perna, 1999, collected in spring 2011 (site 5c). This species (Fig. 2), initially suspected to be an holocene subfossil taxa since it has never been found alive, has been re-

cently reported from various localities of the Tuscan Archipelago and, according to Giusti & Micali (2018), might be actually living. The rather fresh specimen figured by Romani et al. (2016) and the present record are in agreement with such hypothesis.

Among the most widely distributed species, the Mediterranean endemic fan shell, *Pinna nobilis* Linnaeus, 1758, deserves particular attention, with a large population extending from Punta di Croce di Mare to Punta Cala Oliva, starting from 2 m depth. In the same stretch of seafloor, sporadic specimens of *P. rudis* Linnaeus, 1758, also occurred. Both fan shells, which play an important role as habitat builders, are protected species under the European Council Directive 92/43/EEC (Eurpean Economic Community, EEC, 1992), in the ANNEX II of Barcelona Convention and by local law in all the Mediterranean countries of the European Union. Their occurrence in the coastal waters of Milazzo is thus remarkable in the framework of establishing the marine protected area. Mass mortality events that recently affected wide areas in the western Mediterranean, including Cape Milazzo (Cabanellas-Reboredo et al., submitted) further suggest the needing of accurate monitoring of their local populations. Other species under EEC and National protection were the date mussel *Lithophaga lithophaga* (Linnaeus, 1758), widely distributed along the rocky cliffs, the whelks *Charonia lampas* (Linnaeus, 1758) and *Ranella olearia* (Linnaeus, 1758), both recorded in the proposed "zone A" (site 5c), and the cowries *Naria spurca* (Linnaeus, 1758) and *Luria lurida* (Linnaeus, 1758), both apparently localized in Site 3 (Vaccarella-Puntaloro-Cala Oliva). The vermetid *Dendropoma cristatum* (Biondi, 1859) is reported in both the eastern and northern coasts (Sites 4, 4, and 5d), where it forms relevant bioconstructions. Species of high interest were also the whelks *Monoplex parthenopeus* (Salis Marschlins, 1793) (Fig. 3), which is included in the "Red List" of threatened species, and *Bursa scrobilator* (Linnaeus, 1758), not yet considered as endangered, although infrequent in the Mediterranean and actively sought for collection purposes.

Haliotis stomatiaeformis Reeve, 1846 (Fig. 4) is a poorly known species reported only from continental Sicily up to Malta (Geiger, 2000). According to Gaeta et al. (2003), habitat selection might be the ecological factor allowing its coexistence with the common *H. tuberculata tuberculata* Linnaeus, 1758.

The record of *Mathilda bielerei* Smriglio et Mariottini, 2007 (Figs. 5–7), a species not yet dealt with in the scientific literature after its original description in Smriglio et al. (2007), is of relevant interest since it testifies that such species is not strictly tied to the type habitat, the deep-sea coral banks.

The settlement of a small population of the pearl oyster *Pinctata imbricata radiata* (Leach, 1814) (Fig. 8) is of different interest, as it testifies the progressive consolidation and spreading in the western basin of this species of Lessepsian origin, long time naturalized in the eastern basin up to the Ionian coasts of Sicily, with dated occasional reports from Milazzo (Di Natale, 1982) and sporadic records in the western Mediterranean (Lodola et al., 2013). Long time naturalized Lessepsian is also the mussel *Brachidontes pharaonis* (P. Fischer, 1870), whose spread in the central Mediterranean has been initially documented from western Sicily (Sarà et al., 2008). The occurrence of the warm Atlantic sea hare *Aplysia dactylomela* Rang, 1828, spreading in Tyrrhenian sea from Messina Strait since 2011 (Valdés et al., 2013) is a further evidence of ongoing tropicalization processes.

The record, at last, of single shells of *Buccinum undatum* (Linnaeus,1758), *Nassarius turulosus* (Risso, 1826), and *Euspira catena* (da Costa,1778), not included in the present list, suggested the occurrence of offshore würmian age deposits.

On top of the benthic species, other 14 pelagic molluscs have been recorded in the coastal waters of Cape Milazzo. Most of them were shell remains of pteropoda found in bottom sediments of Site 5 (Tab. 2). More interesting, since specimens have been recorded living, were the violet snails stranded along both the eastern (Sites 2 and 3) and western coasts (site 6). Two species have been collected, the common *Janthina pallida* Thompson, 1840, of which massive stranding have been recorded, e.g., in October 1998, and the much less common *J. globosa* Swainson, 1822, which is suspected to be in further rarefaction. Stranding of the pseudothecosomata *Cymbulia peronii* Blainville, 1818, has been also documented along the western coast (Site 6).

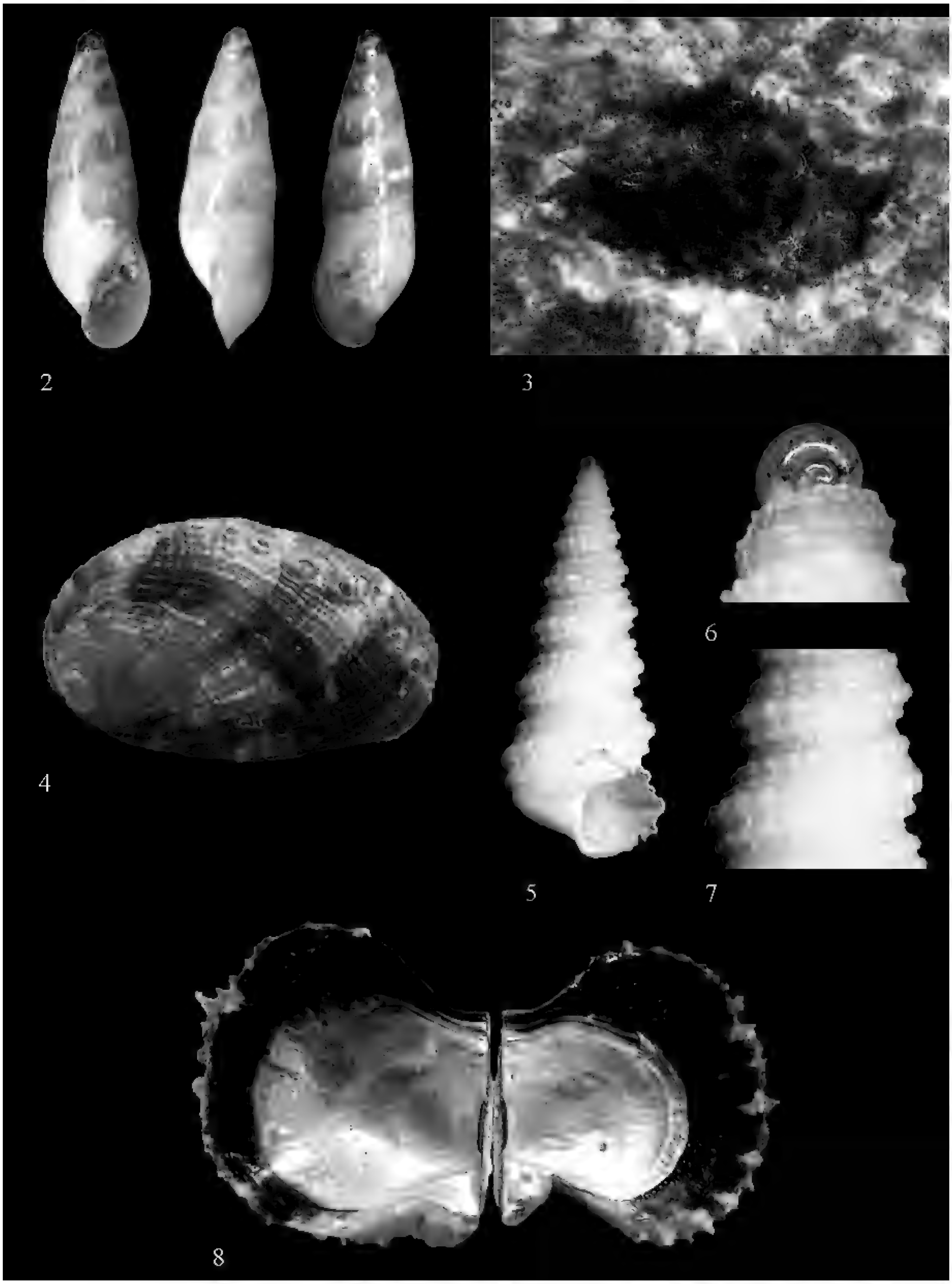

Figure 2. *Haliella tyrrenica*: ventral, dorsal, and lateral view. Figure 3. In situ living specimen of *Monoplex parthenopeus*. Figure. 4. *Haliotis stomatiaeformis*. Figures 5–7. *Mathilda bielerei*. Fig. 6: apex and protoconcha. Fig. 7: detail of ornamentation. Figure 8. *Pinctata imbricata radiata*.

species	site	habitat
POLYPLACOPHORA		
Leptochiton cimicoides (Monterosato, 1879)	3	PM
Leptochiton scabridus (Jeffreys, 1880)	5d	PA
Lepidochitona caprearum (Scacchi, 1836)	5d	PA
Ischnochiton rissoi (Payaraudeau, 1826)	3 5d	PA, PM
Callochiton septemvalvis (Montagu, 1803)	5a	RP
Rhyssoplax corallinus (Risso, 1826)	5d	PA
Chiton olivaceus Spengler, 1797	2 3	PA, PM
Acanthochitona crinita (Pennat, 1777)	2 3	PA, PM
Acanthochitona fascicularis (Linnaeus, 1767)	3 5a	RP, PM
GASTROPODA		
Patella caerulea Linnaeus, 1758	1 2 3 5a, d, e	PA, PM, RP
Patella ulyssiponensis Gmelin, 1791	4	PM
Tectura virginea (O.F. Müller, 1776)	4	PM
Diodora gibberula (Lamarck, 1822)	4	PM
Diodora graeca (Linnaeus, 1758)	2 4	PA, PM
Diodora italica (Defrance, 1820)	2 4	PA, PM
Emarginula adriatica O.G. Costa, 1830	2 4 5c	PA, PM, CD
Emarginula huzardii Payaraudeau, 1826	2 4 5c, d	PA, PM, CD
Emarginula octaviana Coen, 1939	4 5c	PM, CD
Emarginula punctulum Piani, 1980	5c	PM
Emarginula pustula Thiele in Küster, 1913	5b	CD
Emarginula rosea Bell, 1824	5c	PM
Emarginula tenera Locard, 1891	5b, c	CD
Fissurella nubecula (Linnaeus, 1758)	2 3	PA, PM
Anatoma aspera (Philippi, 1844)	5c	PM
Anatoma umbilicata (Jeffreys, 1883)	5d	CD
Scissurella costata d'Orbigny, 1824	2 3 4 5d	PA, PM, CD
Sinezona cingulata (O.G.Costa, 1861)	5c	PM
Haliotis stomatiaeformis Reeve, 1846	3	PA
Haliotis tuberculata tuberculata Linnaeus, 1758	2 3 4	AP, PM
Lepetella espinosae Dantar & Luque, 1994	5b	CD
Clelandella miliaris (Brocchi, 1814)	5c	CD
Gibbula ardens (Salis Marschlins, 1793)	2 4	PA
Gibbula fanulum (Gmelin, 1791)	2 4 5c	PA, PM, CD
Gibbula guttadauri (Philippi, 1836)	4	PM
Gibbula magus (Linnaeus, 1758)	4 5c	PM, CD
Gibbula philberti (Récluz, 1843)	2 5d	PA
Gibbula racketti (Payraudeau, 1826)	2 3	PA, PM
Gibbula turbinoides (Deshayes, 1835)	3 4	PM
Steromphala adansonii (Payraudeau, 1826)	2 4 5a	PA, PM, RP
Steromphala divaricata (Linnaeus, 1758)	2 3 4 5a	PA, PM, RP
Steromphala rarilineata (Michaud, 1829)	3 4	PM
Steromphala umbilicaris (Linnaeus, 1758)	2 4 5a	PA, RP
Steromphala varia (Linnaeus, 1758)	2 3 4	PA, PM
Jujubinus curinii Bogi et Campani, 2006	5b	CD

Table **1/1.** List of the benthic molluscs recorded in Capo Milazzo coastal waters. Sites of collection (1–5) and prevalent habitat of each species are indicated: Photophilic Algae (PA); Phanerogam Meadows (PM); Reef Pools (RP); Coastal Detritic and Biodetritic bottoms (CD); Supratidal Rocky reef (SR).

species	site	habitat
Jujubinus exasperatus (Pennat, 1777)	2 4 5b	PA, PM, CD
Jujubinus gravinae (Dautzenberg, 1881)	5c	CD
Jujubinus montagui (Wood, 1828)	4 5b	PM, CD
Jujubinus striatus (Linnaeus, 1758)	2 4 5b, c	PA, PM, CD
Jujubinus tumidulus (Aradas, 1846)	4 5b	PM, CD
Phorcus articulatus (Lamarck, 1822)	3 4	PM
Phorcus mutabilis (Philippi, 1851)	3 4	PM
Phorcus richardi (Payraudeau, 1826)	3 4 5a	PM, RP
Phorcus turbinatus (Born, 1778)	3 4 5a	PM, RP
Clanculus corallinus (Gmelin, 1791)	3 4 5d	PM, PA
Clanculus cruciatus (Linnaeus, 1758)	2 3 4 5d	PA, PM
Clanculus jussieui (Payraudeau, 1826)	2 3 4 5a, d	PA; PM; RP
Calliostoma conulus (Linnaeus, 1758)	2 4 5b	PA, PM, CD
Cirsonella romettensis (Granata-Grillo, 1877)	5d	PA
Dikoleps depressa (Monterosato, 1880)	5d	PA
Dikoleps marianae Rubio, Dantart et Luque, 1998	5d	PA
Skenea catenoides (Monterosato, 1877)	5d	PA
Skenea serpuloides (Montagu, 1808)	5d	PA
Lissomphalia bithynoides (Monterosato, 1880)	5c	CD
Skeneoides exilissima (Philippi, 1844)	5d	PA
Bolma rugosa (Linnaeus, 1767)	2 3 4 5b	PA, PM, CD
Danilia tinei (Calcara, 1839)	5d	PA
Moelleriopsis messanensis (Seguenza, 1876)	5d	PA
Akritogyra conspicua (Monterosato, 1880)	5d	PA
Homalopoma sanguineum (Linnaeus, 1758)	5b	CD
Tricolia cfr. *entomocheila* Gofas, 1993	5b	CD
Tricolia pullus pullus (Linnaeus, 1758)	2 3 4	PA, PM
Tricolia punctura Gofas, 1993	2 5d	PA
Tricolia speciosa (Megerle von Mühlfeld, 1824)	2 3 4	PA, PM
Tricolia tenuis (Michaud, 1829)	2 3	PA, PM
Tricolia landini Bogi et Campani, 2007	2	PA
Smaragdia viridis (Linnaeus, 1758)	2 3 4	PA, PM
Bittium lacteum (Philippi, 1836)	2 3 4 5d	PA, PM
Bittium latreillii (Payraudeau, 1826)	1 5c, d	PA, CD
Bittium reticulatum (da Costa, 1778)	2 3 4 5a, c, d	PA, PM, RP, CD
Cerithidium submammillatum (De Rayneval et Ponzi, 1854)	2 5d	PA
Cerithium alucastrum (Brocchi, 1814)	2 3 4 5e	PA, PM
Cerithium lividulum Risso, 1826	2 3	AP, PM
Cerithium protractum Bivona Ant. in Bivona And., 1838	4 5d	PM
Cerithium scabridum Philiippi, 1848	2 5b	PA
Cerithium vulgatum Bruguière, 1792	2 3 5a, e	PA, PM
Fossarus ambiguus (Linnaeus, 1758)	4 5d	PA, PM
Tenagodus obtusus (Schumacher, 1817)	5d	PA
Turritella communis Risso, 1826	5b	CD
Turritella turbona Monterosato, 1877	4	PM
Metaxia metaxa (Delle Chiaje, 1828)	5b, c	CD

Table 1/2. List of the benthic molluscs recorded in Capo Milazzo coastal waters. Sites of collection (1–5) and prevalent habitat of each species are indicated: Photophilic Algae (PA); Phanerogam Meadows (PM); Reef Pools (RP); Coastal Detritic and Biodetritic bottoms (CD); Supratidal Rocky reef (SR).

species	site	habitat
Marshallora adversa (Montagu, 1803)	2 5d	PA
Monophorus erythrosoma (Bouchet et Guillemot, 1978)	5e	PM
Monophorus perversus (Linnaeus, 1758)	4 5b, c	PM, CD
Cheirodonta pallescens (Jeffreys, 1867)	3 5d	PA, PM
Krachia cylindrata (Jeffreys, 1885)	5b, c	CD
Krachia tiara (Monterosato, 1874)	5b	CD
Dizoniopsis concatenata (Conti, 1864)	5b, e	PM, CD
Dizoniopsis coppolae (Aradas, 1870)	5d	PM
Cerithiopsis barleei Jeffreys, 1867	5b, d	PA, CD
Cerithiopsis diadema Monterosato,1874	5d	AP
Cerithiopsis fayalensis R.B. Watson,1886	4	HP
Cerithiopsis jeffreysi Watson,1885	5d	AP
Cerithiopsis minima (Brusina, 1865)	2 4 5d	PA, PM
Cerithiopsis scalaris Locard, 1891	5d	PA
Cerithiopsis tubercularis (Montagu, 1803)	5d	PA
Opalia coronata (Philippi & Scacchi, 1840)	4 5c	PM, CD
Cirsotrema pumiceum (Brocchi, 1814)	2	PA
Epitonium clathrus (Linnaeus, 1758)	2 4 5d	PA, PM
Epitonium hispidulum (Monterosato, 1874)	5d	PA
Epitonium muricatum (Risso, 1826)	2 4	PA, PM
Epitonium pulchellum (Bivona, 1832)	5d	PA
Epitonium tiberii (de Boury, 1890)	4 5c	PM, CD
Gyroscala lamellosa (Lamarck, 1822)	3	PM
Acirsa subdecussata (Cantraine, 1835)	5c	CD
Aclis ascaris (W. Turton, 1819)	5d	PA
Eulima bilineata Alder, 1848	5b	CD
Eulima glabra (da Costa, 1778)	5b	CD
Melanella polita (Linnaeus, 1758)	4 5c	PM, CD
Sabinella bonifaciae (F. Nordsieck, 1974)	5b, c	CD
Parvioris ibizenca (Nordsiesck, 1968)	2 5c	PA, CD
Sticteulima jeffreysiana (Brusina, 1869)	5c	CD
Vitreolina curva (Monterosato, 1874)	5b, c	CD
Vitreolina incurva (Bucquoy, Dautzenberg et Dollfus, 1883)	5c	CD
Vitreolina perminima (Jeffreys, 1883)	2 5c	PA, CD
Vitreolina philippi (de Rayneval et Ponzi, 1854)	2 5c	PA, CD
Nanobalcis nana (Monterosato, 1878)	5c	CD
Haliella tyrrhena Di Geronimo et La Perna, 1999	5c	CD
Echinolittorina punctata (Gmelin, 1791)	1 2 5d	SR
Melarhaphe neritoides (Linnaeus, 1758)	5d	SR
Skeneopsis planorbis (O. Fabricius, 1780)	5c	CD
Eatonina cossurae (Calcara, 1841)	3 5d	PA, PM
Eatonina fulgida (J. Adams, 1797)	3 5d	PA, PM
Eatonina ochroleuca (Brusina, 1869)	5b	CD
Eatonina pumila (Monterosato, 1884)	5d	PA
Rissoina bruguieri (Payraudeau, 1826)	1 2 3	PA, PM
Rissoa auriscalpium (Linnaeus, 1758)	2 3	PA, PM

Table 1/3. List of the benthic molluscs recorded in Capo Milazzo coastal waters. Sites of collection (1–5) and prevalent habitat of each species are indicated: Photophilic Algae (PA); Phanerogam Meadows (PM); Reef Pools (RP); Coastal Detritic and Biodetritic bottoms (CD); Supratidal Rocky reef (SR).

species	site	habitat
Rissoa decorata Philippi, 1846	3	PM
Rissoa guerinii Récluz, 1843	2 3	PA, PM
Rissoa italiensis Verduin, 1985	5d	PA
Rissoa lia (Monterosato, 1884)	5a, d	PA, RP
Rissoa membranacea (J. Adams, 1800)	2 5d	PA
Rissoa monodonta Philippi, 1836	2 5d	PA
Rissoa scurra (Monterosato, 1917)	5d	PA
Rissoa similis Scacchi, 1836	2 5a, d	PA, RP
Rissoa variabilis (Megerle von Mühlfeld, 1824)	2 5a, c	PA, RP, CD
Rissoa ventricosa Desmarest, 1814	2 3	PA, PM
Rissoa violacea Desmarest, 1814	3 5d	PM, PA
Alvania beanii (Hanley in Thorpe, 1844)	4	PM
Alvania cancellata (da Costa, 1778)	4 5a, d	PM, RP, PA
Alvania cimex (Linnaeus, 1758)	2 4 5a, d	PA, PM, RP
Alvania cimicoides (Forbes, 1844)	5c	CD
Alvania clathrella L. Seguenza, 1903	5e	CD
Alvania dictyophora (Philippi, 1844)	5e	CD
Alvania discors (T. Allan, 1818)	2 3 4	PA, PM
Alvania gagliniae Amati, 1985	5c	CD
Alvania geryonia (Nardo, 1847)	4 5a	PM, RP
Alvania hallgassi Amati et Oliverio, 1985	5d	PA
Alvania hirta (Monterosato, 1884)	2 5b	PA, CD
Alvania hispidula (Monterosato, 1884)	5c	CD
Alvania lanciae (Calcara, 1845)	2 3 4 5a	PA, PM, RP
Alvania lineata Risso, 1826	2 3 4 5b	PA, PM, CD
Alvania pagodula (Bucquoy, Dautzenberg et Dollfus, 1884)	5b, c	CD
Alvania punctura (Montagu, 1803)	5b, c	CD
Alvania rudis (Philippi, 1844)	5b, c	CD
Alvania scabra (Philippi, 1844)	5a, b, c	RP, CD
Alvania subcrenulata (Bucquoy, Dautzenberg et Dollfus, 1884)	5b	CD
Alvania testae (Aradas et Maggiore, 1844)	5d	CD
Alvania weinkauffi jacobusi Oliverio, Amati et Nofroni, 1986	5d	CD
Alvania zetlandica (Montagu, 1815)	5c	CD
Crisilla beniamina (Monterosato, 1884)	5b	CD
Crisilla semistriata (Montagu, 1808)	5b	CD
Manzonia crassa (Kanmacher, 1798)	2 5c	RP, CD
Obtusella intersecta (S. Wood, 1857)	5c	CD
Obtusella macilenta (Monterosato, 1880)	5c	CD
Botryphallus epidauricus (Brusina, 1866)	5c	CD
Peringiella elegans (Locard, 1891)	1	CD
Pusillina inconspicua (Alder, 1844)	4 5c	PM, CD
Pusillina lineolata (Michaud, 1830)	2 5a 5b	AP, RP, CD
Pusillina marginata (Michaud, 1830)	2	PA
Pusillina philippi (Aradas et Maggiore, 1844)	3	PM
Pusillina radiata (Philippi, 1836)	4	PM
Setia amabilis (Locard, 1886)	5a	RP

Table 1/4. List of the benthic molluscs recorded in Capo Milazzo coastal waters. Sites of collection (1–5) and prevalent habitat of each species are indicated: Photophilic Algae (PA); Phanerogam Meadows (PM); Reef Pools (RP); Coastal Detritic and Biodetritic bottoms (CD); Supratidal Rocky reef (SR).

species	site	habitat
Setia scillae (Aradas et Benoit, 1876)	2	PA
Pisinna glabrata (Megerle von Mühlfeld, 1824)	3	PM
Nodulus contortus (Jeffreys, 1856)	5b	CD
Paludinella globularis (Hanley in Thorpe, 1844)	5a	RP
Barleeia unifasciata (Montagu, 1803)	2 3 5a	PA, PM, RP
Caecum auriculatum De Folin, 1868	2 5d	PA, PM
Caecum clarkii Carpenter, 1859	4	PM
Caecum subannulatum De Folin, 1870	2 5c	CD
Caecum trachea (Montagu, 1803)	1 4 5d	PA, PM
Hyala vitrea (Montagu, 1803)	2 3	PA, PM
Tornus subcarinatus (Montagu, 1803)	5d	PA
Circulus striatus (Philippi, 1836)	5b	CD
Truncatella subcylindrica (Linnaeus, 1767)	2 3 4	PA, PM
Thylacodes arenarius (Linnaeus, 1758)	3	PM
Dendropoma cristatum (Biondi, 1859)	2 3 5d	PA, PM,
Petaloconchus glomeratus (Linnaeus, 1758)	3	PM
Thylaeodus rugulosus (Monterosato, 1878)	2	PA
Aporrhais pespelecani (Linnaeus, 1758)	3 4 5c	PM, CD
Crepidula unguiformis Lamarck, 1822	2 3 4 5b	PA, PM, CD
Calyptraea chinensis (Linnaeus, 1758)	1 4 5b	PA, PM, CD
Capulus ungaricus (Linnaeus, 1758)	4 5c	PM, CD
Lamellaria perspicua (Linnaeus, 1758)	3 5d	PA, PM
Erato voluta (Montagu, 1803)	5d	PA
Trivia arctica (Pulteney, 1799)	1 2 4 5c	PA, PM, CD
Trivia mediterranea (Risso, 1826)	1 4	PM
Trivia monacha (da Costa, 1778)	4	PM
Luria lurida (Linnaeus, 1758)	2 3	AP, PM
Naria spurca (Linnaeus, 1758)	3	PM
Simnia spelta (Linnaeus, 1758)	5b	CD
Pseudosimnia carnea (Poiret, 1789)	5b	CD
Naticarius stercusmuscarum (Gmelin, 1791)	2 3 4 5c	PM, CD
Naticarius hebraeus (Martyn, 1786)	3 4 5c	PM, CD
Notocochlis dillwynii Payaraudeau, 1826	3	PM
Tectonatica sagraiana (d'Orbigny, 1842)	2 3	PM, CD
Euspira fusca (Blainville, 1825)	5b	CD
Euspira intricata (Donovan, 1804)	2 3 4	PM, CD
Euspira macilenta (Philippi, 1844)	4	PM
Euspira nitida (Donovan, 1804)	1 4	PM
Galeodea echinophora (Linnaeus, 1758)	2	CD
Neverita josephinia Risso, 1826	2 3	PM
Semicassis granulata (Born, 1778)	3	PM
Ranella olearium (Linnaeus, 1758)	5c	CD
Charonia lampas (Linnaeus, 1758)	5c	CD
Monoplex corrugatus (Lamarck, 1816)	3	PM
Monoplex parthenopeus (Salis Marschlins, 1793)	5c	CD
Cabestana cutacea (Linnaeus, 1767)	4	PM

Table 1/5. List of the benthic molluscs recorded in Capo Milazzo coastal waters. Sites of collection (1–5) and prevalent habitat of each species are indicated: Photophilic Algae (PA); Phanerogam Meadows (PM); Reef Pools (RP); Coastal Detritic and Biodetritic bottoms (CD); Supratidal Rocky reef (SR).

species	site	habitat
Bursa scrobilator (Linnaeus, 1758)	5d	PA
Hexaplex trunculus (Linnaeus, 1758)	2 3 4 5c	PA, PM, CD
Dermomurex scalaroides (Blanville, 1829)	4 5a	PM, RP
Ocenebra edwardsii (Payraudeau, 1826)	3	PM
Ocenebra erinaceus (Linnaeus, 1758)	4	PM
Ocinebrina aciculata (Lamarck, 1822)	2 4 5b, c	PA, PM, CD
Hadriania craticulata Bucquoy et Dautzenberg, 1882	2 5c	CD
Murexsul aradasii (Monterosato in Poirier, 1883)	5b, c	CD
Muricopsis cristata (Brocchi, 1814)	2 5d	PA
Typhinellus labiatus (de Cristofori et Jan,1832)	2 3	PA, PM
Pagodula echinata (Kiener, 1840)	5c	CD
Trophonopsis barvicensis (Johnston, 1825)	5c	CD
Stramonita haemastoma (Linnaeus, 1767)	1 2 3 4	PA, PM
Coralliophila brevis (Blainville, 1832)	5c, d	CD, PM
Coralliophila meyendorffii (Calcara, 1845)	3	PA
Hirtomurex squamosus (Bivona Ant. in Bivona And., 1838)	5d	PA
Volvarina mitrella (Risso, 1826)	4 5d	PM
Granulina marginata (Bivona, 1832)	2 5a, d	PA, PM, RP
Granulina mediterranea Landau, La Perna et Marquet, 2006	4	PM
Granulina occulta (Monterosato, 1896)	5b	CD
Gibberula miliaria (Linnaeus, 1758)	2 3 4 5d	PA, PM
Gibberula philippi (Monterosato, 1878)	2 4 5a, d	PN, PA, RP
Gibberula recondita Monterosato, 1884	2 5d	PA
Isara cornea (Lamarck,1811)	3 5d	PA, PM
Episcomitra cornicula (Linnaeus, 1758)	2 4 5b	PA, PM, CD
Pusia ebenus (Lamarck, 1811)	2 4	PA, PM
Pusia savignyi (Payraudeau, 1826)	2 3 5d	PA, PM
Pusia tricolor (Gmelin, 1791)	2 4 5a, d	PA, PM, RP
Euthria cornea (Linnaeus, 1758)	2 4	PA, PM
Pisania striata (Gmelin, 1791)	2 4	PA, PM
Chauvetia lefebvrii (Maravigna, 1840)	5b, c	CD
Chauvetia mamillata (Risso, 1826)	4 5b, c	PM, CD
Chauvetia procerula (Monterosato, 1889)	5b, c	CD
Chauvetia recondita (Brugnone, 1873)	5d	PA
Chauvetia turritellata (Deshayes, 1835)	5b, c	CD
Aplus dorbignyi (Payraudeau, 1826)	2 3	PA, PM
Cumia reticulata (Blainville, 1829)	4 5b	PM, CD
Tritia corniculum (Olivi, 1792)	5d	PA
Tritia cuvierii (Payraudeau, 1826)	2 3 4	PA, PM
Tritia lima (Dillwyn, 1817)	4 5b, c	PM, CD
Tritia mutabilis (Linnaeus, 1758)	2	PA
Tritia neritea (Linnaeus, 1758)	2 3	PA, PM
Tritia pygmaea (Lamarck, 1822)	2 3	PA, PM
Columbella rustica (Linnaeus, 1758)	2 3 4 5a	PA, PM, RP
Mitrella coccinea (Philippi, 1836)	5d	PA
Mitrella scripta (Linnaeus, 1758)	2 5a, b, c	PA, RP, CD

Table 1/6. List of the benthic molluscs recorded in Capo Milazzo coastal waters. Sites of collection (1–5) and prevalent habitat of each species are indicated: Photophilic Algae (PA); Phanerogam Meadows (PM); Reef Pools (RP); Coastal Detritic and Biodetritic bottoms (CD); Supratidal Rocky reef (SR).

species	site	habitat
Tarantinaea lignaria (Linnaeus, 1758)	4	PM
Aptyxis syracusana (Linnaeus, 1758)	3	PM
Fusinus dimassai Buzzurro et Russo, 2007	5c	CD
Fusinus parvulus (Monterosato, 1884)	5b	CD
Fusinus pulchellus (Philippi, 1840)	4 5c	PM, CD
Fusinus rostratus (Olivi, 1792)	5c	CD
Crassopleura maravignae (Bivona Ant. in Bivona And., 1838)	5c	CD
Haedropleura septangularis (Montagu, 1803)	2 5b	PA, CD
Drilliola emendata (Monterosato, 1872)	5c	CD
Drilliola loprestiana (Calcara, 1841)	5c	CD
Mitromorpha olivoidea (Cantraine, 1835)	2 4 5d	PA, PM
Clathromangelia granum (Philippi, 1844)	4 5a, d	PM, RP, PA
Comarmondia gracilis (Montagu, 1803)	4 5c	PM, CD
Conus ventricosus Gmelin, 1791	2 3 4	PA, PM
Raphitoma atropurpurea (Locard et Caziot, 1900)	5c	CD
Raphitoma concinna (Scacchi, 1836)	2 4 5d	PA, PM
Raphitoma echinata (Brocchi, 1814)	2 5c	PA, CD
Raphitoma laviae (Philippi, 1844)	4 5c	PM, CD
Raphitoma leufroyi (Michaud, 1828)	5d	PA
Raphitoma linearis (Montagu, 1803)	2 4 5c	PA, PM, CD
Raphitoma lineolata (Bucquoy, Dautzenberg et Dollfus, 1883)	2 5c	AP, CD
Teretia teres (Reeve, 1844)	5b, c	CD
Sorgenfreispira brachystoma (Philippi, 1844)	2 4 5c	PA, PM,CD
Bela decussata (Locard, 1891)	5c	CD
Bela menkhorsti van Aarten, 1988	2 5c	PA, CD
Bela nebula (Montagu, 1803)	1 2 4	PA, PM
Bela zenetouae (van Aarten, 1988)	5c	CD
Mangelia attenuata (Montagu, 1803)	2 4 5b	PA, PM, CD
Mangelia costata (Pennant, 1777)	2 5b, c	PA, CD
Mangelia costulata Risso, 1826	2 4 5b	PA, PM, CD
Mangelia multilineolata (Deshayes, 1835)	4 5b, c	PM, CD
Mangelia paciniana (Calcara, 1839)	5b	CD
Mangelia striolata Risso, 1826	2 5b	PA, CD
Mangelia taeniata (Deshayes, 1835)	2 4 5b	PA, PM, CD
Mangelia unifasciata (Deshayes, 1835)	2 4 5d	PA, PM, CD
Mangelia vauquelini (Payraudeau, 1826)	5d	PA
Basisulcata lepida (Bayer, 1942)	5c	CD
Philippia hybrida (Linnaeus, 1758)	5c	CD
Discotectonica discus (Philippi, 1844)	5c	CD
Solatisonax alleryi (Seguenza G., 1876)	5c	CD
Heliacus fallaciosus (Tiberi, 1872)	5c	CD
Pseudotorinia architae (O.G. Costa,1841)	5c	CD
Mathilda bieleri Smriglio et Mariottini, 2007	5c	CD
Mathilda cochlaeformis Brugnone, 1873	5c	CD
Rissoella inflata (Monterosato, 1880)	2 5c	PA, CD
Rissoella opalina (Jeffreys, 1848)	2 5c	PA, CD

Table 1/7. List of the benthic molluscs recorded in Capo Milazzo coastal waters. Sites of collection (1–5) and prevalent habitat of each species are indicated: Photophilic Algae (PA); Phanerogam Meadows (PM); Reef Pools (RP); Coastal Detritic and Biodetritic bottoms (CD); Supratidal Rocky reef (SR).

species	site	habitat
Ammonicera fischeriana (Monterosato, 1869)	2 5c	PA, CD
Ammonicera rota (Forbes et Hanley, 1850)	2 5c	PA, CD
Omalogyra atomus (Philippi, 1841)	2 5c	PA, CD
Omalogyra simplex (Costa O.G., 1861)	2 5c	PA, CD
Retrotortina fuscata Chaster, 1896	5c	CD
Tomura depressa (Granata-Grillo, 1877)	2 5c	PA, CD
Xenoskenea pellucida (Monterosato, 1874)	2 5c	PA, CD
Odostomia acuta Jeffreys, 1848	2 5b	PA, CD
Odostomia suboblonga Jeffreys, 1884	5d	PA
Odostomia turrita Hanley, 1844	5d	PA
Brachystomia scalaris MacGillivray, 1843	2 5b	PA, CD
Megastomia alungata (Nordiesck, 1972)	2 5d	PA
Megastomia conoidea (Brocchi, 1814)	2 5a, d	PA, RP
Euparthenia humboldti (Risso, 1826)	4 5b, d	PM, CD
Folinella excavata (Phillippi, 1836)	2 4 5b	PA, PM, CD
Ondina crystallina Locard, 1891	2	PA
Ondina vitrea (Brusina, 1866)	2 5d	PA
Ondina warreni (Thompson, 1845)	5d	PA
Chrysallida stefanisi (Jeffreys, 1869)	5b	CD
Parthenina clathrata (Jeffreys, 1848)	5b	CD
Parthenina decussata (Montagu, 1803)	5d	PA
Parthenina emaciata (Brusina, 1866)	2 5b, d	PA, CD
Parthenina interstincta (J. Adams, 1797)	2 5b	PA, CD
Parthenina monozona (Brusina, 1869)	2 4 5b	PA, PM, CD
Tragula fenestrata (Jeffreys, 1848)	2 5d	PA
Odostomella bicincta (Tiberi, 1868)	5d	PA
Odostomella doliolum (Philippi, 1844)	2 3 5b	PA, PM, CD
Turbonilla acuta (Donovan, 1804)	2 5b	PA, CD
Turbonilla acutissima Monterosato, 1884	2 5b	PA, CD
Turbonilla edgari (Melvill, 1896)	5b	CD
Turbonilla gradata Bucquoy, Dautzenberg et Dollfus, 1883	2 5b	PA, CD
Turbonilla lactea (Linnaeus, 1758)	2 4 5b, c	PA, PM, CD
Turbonilla pusilla (Philippi, 1844)	5b	CD
Pyrgiscus jeffreysii (Jeffreys, 1848)	2 4 5b	PA, PM, CD
Pyrgiscus rufus (Philippi, 1836)	2 4 5b	PA, PM, CD
Pyrgostylus striatulus (Linnaeus, 1758)	2 4 5b	PA, PM, CD
Eulimella acicula (Philippi, 1836)	2 5b, d	PA, CD
Eulimella cerulli (Cossmann, 1916)	2 5b, d	PA, CD
Eulimella scillae (Scacchi, 1835)	4 5b, d	PA, CD
Eulimella ventricosa (Forbes, 1844)	2 5b, d	PA, CD
Clathrella clathrata (Philippi, 1844)	5b	CD
Ebala nitidissima (Montagu, 1803)	5b	CD
Ebala pointeli (de Folin, 1868)	4 5b	PM, CD
Cima minima (Jeffreys, 1858)	2 5b	PA, CD
Ringicula auriculata (Ménard de la Groye, 1811)	2 5b, c	PA, CD
Ringicula conformis Monterosato, 1877	2 5b	PA. CD

Table 1/8. List of the benthic molluscs recorded in Capo Milazzo coastal waters. Sites of collection (1–5) and prevalent habitat of each species are indicated: Photophilic Algae (PA); Phanerogam Meadows (PM); Reef Pools (RP); Coastal Detritic and Biodetritic bottoms (CD); Supratidal Rocky reef (SR).

species	site	habitat
Bulla striata Bruguière, 1792	2 3	PA, PM
Retusa crebrisculpta (Monterosato, 1884)	2 5b	PA, CD
Retusa leptoeneilema (Brusina, 1866)	1 2 5c	PA,CD
Retusa mammillata (Philippi, 1836)	1 5b	PA, CD
Retusa minutissima (Monterosato, 1878)	2 5b	PA, CD
Retusa truncatula (Bruguière, 1792)	2 4 5b	PA, PM, CD
Retusa umbilicata (Montagu, 1803)	2 5b	PA, CD
Pyrunculus hoernesi (Weinkauff, 1866)	5b, c	CD
Volvulella acuminata (Bruguière, 1792)	2 4 5b, c	PA, PM, CD
Haminoea sp.	2 4 5b	PA, PM, CD
Atys jeffreysi (Weinkauff, 1866)	4 5c	PM, CD
Weinkauffia turgidula (Forbes, 1844)	2 5c	PA, CD
Hermania scabra (O.F. Müller, 1784)	2 4 5c	PA, PM, CD
Philine angulata Jeffreys, 1867	5b	CD
Philine catena (Montagu, 1803)	4 5c	PM, CD
Philine denticulata (J. Adams, 1800)	5d	PA
Philine intricata Monterosato, 1884	5b, d	CD, PA
Philine sp.	5c	CD
Philine punctata (J. Adams, 1800)	5c	CD
Philine quadripartita Ascanius, 1772	1	PA
Philine striatula Monterosato, 1874	2 5c	PA, CD
Scaphander lignarius (Linnaeus, 1758)	4	PM
Roxania utriculus (Brocchi, 1814)	2 4 5c	PA, PM, CD
Cylichna cylindracea (Pennat, 1777)	5b, c	CD
Umbraculum umbraculum (Lightfoot, 1786)	5c	CD
Tylodina perversa (Gmelin, 1791)	5d	PA
Berthella aurantiaca (Risso, 1818)	5d	PA
Berthella plumula (Montagu, 1803)	5d	PA
Berthella stellata (Risso, 1826)	5d	PA
Aplysia dactylomela Rang, 1828	5e	PM
Petalifera petalifera (Rang, 1828)	2	PA
Notarchus punctatus Philippi, 1836	4 5b	PM, CD
Williamia gussoni (Costa O.G., 1829)	4 5b	PM, CD
BIVALVIA		
Nucula nitidosa Winckworth, 1930	1 2	PA
Nucula nucleus (Linnaeus, 1758)	4	PM
Nucula sulcata Bronn, 1831	2 4 5b, c, d	PA, PM, CD
Lembulus pella (Linnaeus, 1758)	1 2 3 4 5b	PA, PM, CD
Saccella commutata (Philippi, 1844)	4 5b	PM, CD
Yoldiella philippiana (Nyst, 1845)	5b 5c	CD
Arca noae Linnaeus, 1758	1 2 3 4 5a, b	PA, PM, RP, CI
Arca tetragona Poli, 1795	1 4 5b,c	PA, PM, CD
Asperarca nodulosa (O F. Müller, 1776)	4 5b, c	PM, CD
Asperarca secreta La Perna, 1998	2 5b, c, d	PA, CD
Barbatia barbata (Linnaeus, 1758)	1 2 3 4	PA, PM
Acar clathrata (Defrance, 1816)	4 5c	PM, CD

Table 1/9. List of the benthic molluscs recorded in Capo Milazzo coastal waters. Sites of collection (1–5) and prevalent habitat of each species are indicated: Photophilic Algae (PA); Phanerogam Meadows (PM); Reef Pools (RP); Coastal Detritic and Biodetritic bottoms (CD); Supratidal Rocky reef (SR).

species	site	habitat
Anadara gibbosa (Reeve, 1844)	4	PM
Bathyarca pectunculoides (Scacchi, 1835)	5b	CD
Striarca lactea (Linnaeus, 1758)	1 5b	PA, CD
Limopsis tenuis Seguenza, 1876	2 3 4 5c	CD
Glycymeris bimaculata (Poli, 1795)	2 3 4	PM
Glycymeris glycymeris (Linnaeus, 1758)	2 3 4	PM
Mytilus edulis Linnaeus, 1758	3	AP
Mytilus galloprovincialis Lamarck, 1819	1 2 3	AP
Brachidontes pharaonis (P. Fischer, 1870)	1 2 3	AP
Mytilaster solidus Monterosato, 1883	1 2	AP
Crenella arenaria Monterosato, 1875 ex H. Martin, ms.	5c	CD
Gregariella petagnae (Scacchi, 1832)	5c	CD
Gregariella semigranata (Reeve, 1858)	1 2 4 5c, d	PA, PM, CD
Musculus costulatus (Risso, 1826)	1 2 3 4 5b	PA, PM, CD
Musculus discors (Linnaeus, 1767)	5d	PA
Musculus subpictus (Cantraine, 1835)	4 5b	PM, CD
Rhomboidella prideauxi (Learch, 1815)	4 5c	PM, CD
Lithophaga lithophaga (Linnaeus, 1758)	1 2 5d	PA
Modiolus barbatus (Linnaeus, 1758)	1 2 3 4	PA, PM
Gibbomodiola adriatica (Lamarck, 1819)	2 5c	PA, CD
Dacrydium hyalinum (Monterosato, 1875)	3 5b, c	PM, CD
Modiolula phaseolina (Philippi, 1844)	4 5c, d	PM, PA, CD
Pinna nobilis Linnaeus, 1758	2 3 4 5d, e	PA, PM
Pinna rudis Linnaeus, 1758	3	PM
Pinctada imbricata radiata (Leack, 1814)	3	PM
Similipecten similis (Laskey, 1811)	4	PM
Pecten jacobaeus (Linnaeus, 1758)	2 4 5c	PM, CD
Flexopecten flexuosus (Poli, 1795)	2 4 5b, c, d	PA, PM, CD
Flexopecten glaber (Linnaeus, 1758)	2 4 5d	PA, PM
Flexopecten hyalinus (Poli, 1795)	2 4 5b	PA, PM, CD
Aequipecten commutatus (Monterosato, 1875)	4 5b	PM, CD
Aequipecten opercularis (Linnaeus, 1758)	4	PM
Mimachlamys varia (Linnaeus, 1758)	2 4 5b	PA, PM, CD
Palliolum incomparabile (Risso, 1826)	4 5b 5e	PM, CD
Pseudamussium clavatum (Poli, 1795)	4 5b	PM, CD
Delectopecten vitreus (Gmelin, 1791)	5c	CD
Manupecten pesfelis (Linnaeus, 1758)	4	PM
Talochlamys multistriata (Poli, 1795)	2 4 5e	PA, PM
Spondylus gaederopus Linnaeus, 1758	1 2 3 4 5d	PA, PM
Anomia ephippium Linnaeus, 1758	1 2 3 4 5d, e	PA, PM
Heteranomia squamula (Linnaeus, 1758)	5e	PM
Pododesmus patelliformis (Linnaeus, 1761)	3 5d	PA, PM
Lima lima (Linnaeus, 1758)	2 3	PA, PM
Limaria hians (Gmelin, 1791)	2 4 5d, e	PA, PM
Limaria tuberculata (Olivi, 1792)	5b	CD
Limatula gwyni (Sykes, 1903)	4 5b	PM, CD

Table 1/10. List of the benthic molluscs recorded in Capo Milazzo coastal waters. Sites of collection (1–5) and prevalent habitat of each species are indicated: Photophilic Algae (PA); Phanerogam Meadows (PM); Reef Pools (RP); Coastal Detritic and Biodetritic bottoms (CD); Supratidal Rocky reef (SR).

species	site	habitat
Limatula subauriculata (Montagu, 1808)	5b	CD
Ostrea edulis Linnaeus, 1758	1 2 3 5c, d	PA, PM, CD
Crassostrea gigas (Thunberg, 1793)	1 2 4	PA, PM
Neopycnodonte cochlear (Poli, 1795)	4 5b, c	PM, CD
Ctena decussata (O.G. Costa, 1829)	1 2 3 4 5d	PA, PM
Loripinus fragilis (Philippi, 1836)	2 3 4	PM
Loripes orbiculatus Poli, 1791	2 3	PM
Myrtea spinifera (Montagu, 1803)	4 5b	PM, CD
Lucinoma borealis (Linnaeus, 1767)	4	PM
Lucinella divaricata (Linnaeus, 1758)	1 3 4 5d	PM, CD
Axinulus alleni Carrozza, 1981	1	PM
Thyasira biplicata (Philippi, 1836)	1	PM
Diplodonta intermedia Biondi-Giunti, 1859	1	PM
Diplodonta rotundata (Montagu, 1803)	4	PM
Diplodonta trigona (Scacchi, 1835)	5b	CD
Chama gryphoides Linnaeus, 1758	1 2 3 4	PA, PM
Pseudochama gryphina (Lamarck, 1819)	2 3 4	PA, PM
Kellia suborbicularis (Montagu, 1803)	5c	CD
Hemilepton nitidum (W.Turton, 1822)	2 5c	PA, CD
Kurtiella bidentata (Montagu, 1803)	5d	PA
Epilepton clarkiae (W. Clark, 1852)	1	PA
Neolepton sulcatulum (Jeffreys, 1859)	2 5b 5c	PA, CD
Cardita calyculata (Linnaeus, 1758)	3	PM
Centrocardita aculeata (Poli, 1795)	3 4 5b 5c	PM, CD
Glans trapezia (Linnaeus, 1767)	2 3 4	PA, PM
Coripia corbis (Philippi, 1836)	5c	CD
Cardites antiquatus (Linnaeus, 1758)	2 3 4	PA, PM
Astarte fusca (Poli, 1791)	4 5c	PM, CD
Astarte sulcata (da Costa, 1778)	4 5c	PM, CD
Digitaria digitaria (Linnaeus, 1758)	4 5d	PA, PM
Goodallia micalii Giribet & Peñas, 1999	5c	CD
Goodallia pusilla (Forbes, 1844)	5c 5d	PA, CD
Goodallia triangularis (Montagu, 1803)	4 5c 5d	PM, CD
Gonilia calliglypta (Dall, 1903)	5c 5d	CD
Acanthocardia paucicostata (G.B. Sowerby II, 1834)	1 2 3	PM
Acanthocardia tubercolata (Linnaeus, 1758)	3	PM
Parvicardium exiguum (Gmelin, 1791)	2 4	PA, PM
Parvicardium minimum (Philippi, 1836)	1 2 3 4 5d	PM
Papillicardium papillosum (Poli, 1791)	1 2 4 5b	PM
Laevicardium crassum (Gmelin, 1791)	4	PM
Laevicardium oblongum (Gmelin, 1791)	4 5c	PM, CD
Cerastoderma edule (Linnaeus, 1758)	2 3	PM
Mactra stultorum (Linnaeus, 1758)	2	PM
Spisula subtruncata (da Costa, 1778)	1 4	PM
Moerella distorta (Poli, 1791)	1 2 4	PM
Bosemprella incarnata (Linnaeus, 1758)	2	PM

Table 1/11. List of the benthic molluscs recorded in Capo Milazzo coastal waters. Sites of collection (1–5) and prevalent habitat of each species are indicated: Photophilic Algae (PA); Phanerogam Meadows (PM); Reef Pools (RP); Coastal Detritic and Biodetritic bottoms (CD); Supratidal Rocky reef (SR).

species	site	habitat
Peronidia albicans (Gmelin, 1791)	2	PM
Peronaea planata (Linnaeus, 1758)	2	PM
Moerella pulchella (Lamarck, 1818)	2	PM
Serratina serrata (Brocchi, 1814)	2 4	PM, CD
Moerella donacina (Linnaeus, 1758)	2 4 5d	PM
Asbjornsenia pygmaea (Lovén, 1846)	4	PM
Arcopella balaustina (Linnaeus, 1758)	4 5e	PM
Gastrana fragilis (Linnaeus, 1758)	2	PM
Donax semistriatus Poli, 1759	2 5d	PM
Donax variegatus (Gmelin, 1791)	2 4 5d	PM
Gari costulata (W.Turton, 1822)	4	PM
Gari depressa (Pennant, 1777)	3	PM
Gari fervensis (Gmelin, 1791)	1 4	PM
Gari tellinella (Lamarck, 1818)	5b	CD
Abra alba (W. Wood, 1802)	1 4 5d	PM
Abra longicallus (Scacchi, 1835)	2 4	PM
Abra nitida (O.F. Müller, 1776)	1 2	PM
Abra prismatica (Montagu, 1808)	1 4	PM
Abra tenuis (Montagu, 1803)	2	PM
Scrobicularia cottardii (Payraudeau, 1826)	1 3	PM
Scrobicularia plana (da Costa, 1778)	2	PM
Azorinus chamasolen (da Costa, 1778)	2	PM
Solecurtus scopula (W. Turton, 1822)	4	PM
Solecurtus strigilatus (Linnaeus, 1758)	3	PM
Venus casina Linnaeus, 1758	4 5b	PM, CD
Venus verrucosa Linnaeus, 1758	2 3 4	PM
Gouldia minima (Montagu, 1803)	1 3 4 5b	PM, CD
Chamelea gallina (Linnaeus, 1758)	2 3	PM
Clausinella fasciata (da Costa, 1778)	4	PM
Timoclea ovata (Pennat, 1777)	1 2 3 4 5b	PM, CD
Pitar rudis (Poli, 1795)	2 4 5e	PM
Callista chione (Linnaeus, 1758)	1 2 3 4	PM
Polititapes aureus (Gmeli, 1791)	2	PM
Polititapes rhomboides (Pennat, 1777)	2	PM
Ruditapes decussatus (Linnaeus, 1758)	2	PM
Irus irus (Linnaeus, 1758)	2 4 5d	PA, PM
Dosinia lupinus (Linnaeus, 1758)	1 3	PM
Lajonkairia lajonkairii (Payraudeau, 1826)	2 4 5a, d	PA, PM, RP
Lajonkairia substriata Montagu, 1808	5c	CD
Corbula gibba (Olivi, 1792)	1 2 4 5d	PM
Rocellaria dubia (Pennat, 1777)	1 2 4 5b, d	PA, PM, CD
Hiatella arctica (Linnaeus, 1767)	2 5c	PA, CD
Hiatella rugosa (Linnaeus, 1767)	1 2 3 4 5c	PA, PM, CD
Xylophaga dorsalis (W. Turton, 1819)	2 5c	PA, CD
Bryopa aperta (G.B. Sowerby I, 1823)	5b	CD
Bryopa melitensis (Broderip, 1834)	5b	CD

Table 1/12. List of the benthic molluscs recorded in Capo Milazzo coastal waters. Sites of collection (1–5) and prevalent habitat of each species are indicated: Photophilic Algae (PA); Phanerogam Meadows (PM); Reef Pools (RP); Coastal Detritic and Biodetritic bottoms (CD); Supratidal Rocky reef (SR).

species	site	habitat
Cuspidaria cuspidata (Olivi, 1792)	4	PM
Cardiomya costellata (Deshayes, 1835)	1 4 5b	PM, CD
SCAPHOPODA		
Antalis agilis (M. Sars in G.O. Sars, 1872)	2 5d	CD
Antalis inaequicostata (Dautzenberg,1891)	2 4	PM
Antalis vulgaris (da Costa, 1778)	4 5d	PM
Fustiaria rubescens (Deshayes, 1825)	2 4	PM

Table 1/13. List of the benthic molluscs recorded in Capo Milazzo coastal waters. Sites of collection (1–5) and prevalent habitat of each species are indicated: Photophilic Algae (PA); Phanerogam Meadows (PM); Reef Pools (RP); Coastal Detritic and Biodetritic bottoms (CD); Supratidal Rocky reef (SR).

Species	Site
Janthina globosa Wainson,1822	2,3,6
Janthina pallida W. Thompson,1840	2,3,6
Atlanta peronii Lesueur,1817	5c
Cavolinia inflexa (Lesueur, 1813)	5b, c
Diacria trispinosa (Lesueur, 1821)	5d
Clio pyramidata Linnaeus, 1767	2,5c
Creseis clava (Rang, 1828)	5b, c
Styliola subula (Quoy et Gaimard, 1827)	5b, c
Limacina bulimoides (d'Orbigny, 1835)	5c
Limacina retroversa (J. Fleming, 1823)	5c
Limacina trochiformis (d'Orbigny, 1835)	5c
Heliconoides inflatus (d'Orbigny, 1835)	5c
Cymbulia peronii Blainville, 1818	2,3,6
Peracle reticulata (d'Orbigny, 1835)	5c

Table 2. List of the pelagic molluscs recorded in Capo Milazzo coastal waters. Sites of collection of each species (2, 3, 6) are indicated.

CONCLUSIONS

The check-list of 556 benthic taxa here provided, although not exhaustive of the overall biodiversity of the Milazzo Peninsula, may be considered at least representative of the local mollusc fauna and respective habitats, some of which of relevant conservative values, i.e., phanerogam meadows and the more localized vermetid reefs. Most mollusc species under EEC and National protection, and other ones listed as threatened, occur in the coastal seafloors of the Milazzo peninsula, even in areas submitted to relevant anthropogenic pressure.

In the meantime, the settlement of not indigenous species, mainly of tropical origin, together with disease affecting threatened organisms under EEC protection, testified vulnerability of the local ecosystem toward the global change menaces.

The recent establishment of a marine protected area is an important initiative to protect the most sensitive and most valuable natural habitats, and offers new opportunities to improve their knowledge and conservation. Few data are available today on the local biodiversity of these ecosystems, which should be rapidly investigated in order to evaluate the effect of the protection measures as well as any change in valuable habitats not subject to special protection measures. It must be emphasized, in fact, that the local interdiction to human activities cannot protect the marine reserve against the effects of anthropic pressure on the vast territory, which in the Milazzo area are mainly linked to the presence of oil rigs and related oil tanker traffic.

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Diversity of Decapod Crustaceans in Lasongko Bay, Southeast Sulawesi, Indonesia

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ABSTRACT

The aim of this study was to reveal the species diversity of Decapod Crustaceans in Lasongko Bay, Southeast Sulawesi, Indonesia. The study was conducted from April 2013 to March 2014. The sample collections were conducted on a monthly basis using gillnets at six stations. The abundance, diversity, and similarity indices of decapod species are presented spatially and temporally. Nineteen families and thirty-eight species were found in the bay, and they were dominated by the brachyuran group. The Shannon-Weiner diversity index, the evenness index, and the Simpson dominance index of the decapods spatially ranged 0.812–0.893, 0.592–0.683, and 0.215–0.313, respectively. The species similarity index ranged 0.560–0.831 spatially and 0.363–0.902 temporally. Decapods with high economic value were also discussed.

KEY WORDS Abundance; Brachyura; Muna Island; Crustacea; similarity.

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INTRODUCTION

The decapod crustaceans, consisting of crabs (Brachyura) and shrimps (Macrura), play important ecological roles (Aswandy, 2008) and have a high economic value in some species. Some species of decapods are high-value resources and become protein sources for human, such as penaeid shrimp, lobsters (*Panurilus* spp.), mud crabs (*Scylla* spp.), and blue swimming crabs (*Portunus pelagicus* Linnaeus, 1758). There are 14,756 different species of decapods in the world (De Grave et al., 2009), and brachyuran groups range from 5,000 to 10,000 species (Chakravarty et al., 2016), of which about 6793 species inhabit marine ecosystems (Ng et al., 2008; Kumaralingam et al., 2013).

Indonesian waters have a high diversity of decapod crustaceans, but are still poorly documented (Hutomo & Moosa, 2005). The decapod crustaceans found in Indonesian marine waters are about 1502 species, comprising 1,400 species of the brachyura group and 102 species of the Stomatopod group (Hutomo & Moosa, 2005). Researches on decapod crustaceans diversity in Indonesian marine waters have been carried out by Moosa (1980), Moosa & Aswandy (1994), Widyastuti (2007), Aswandy (2008), Pratiwi (2010, 2012), Pratiwi & Astuti (2012), Pratiwi & Widyastuti (2013), Pratiwi & Wijaya (2013), Anggorowati (2014), Anggraeni et al.

(2015), Mashar et al. (2014, 2015), Ardika et al. (2015), Wardiatno et al. (2015a, b), and Wardiatno et al. (2016a, b). The results of several studies have shown that the diversity of decapod species varied across locations and many of the studies still emphasized on the spatial aspect, whereas the diversity of decapod crustaceans was associated with season variability (Andrade et al., 2015). In terms of location, most of research on the biodiversity in Indonesia has been concentrated in the western region.

Lasongko Bay is a small bay located in Central Buton, Southeast Sulawesi, in the eastern part of Indonesia. The bay has been the fishing ground of the blue swimming crab fishery, and many biological aspects of the blue swimming crab in the bay have been reported, i.e., reproductive aspects (Hamid et al., 2015a, b; Hamid et al., 2016a), population dynamic and stock (Hamid & Wardiatno, 2015; Hamid et al., 2016a, c, d), and fishery management (Hamid et al., 2017). In the blue swimming crab fishery, many of the other Decapod Crustacean species are also caught as bycatch. This study aimed to reveal the diversity of decapod crustacean species spatially and temporally in Lasongko Bay, Southeast Sulawesi, Indonesia.

MATERIAL AND METHODS

Study area

The study was conducted in Lasongko Bay, Central Buton, Southeast Sulawesi - Indonesia. The bay is located at the latitude 05°15’ to 05°27’S and longitude 122°27’ to 122°33’E (Figure 1). Decapods have been collected on six stations situated from the inner to the middle part of the bay. Stations 1 to 5 are situated in the area between lower intertidal and subtidal zone. The seagrass was present in the area between lower intertidal and upper subtidal zone with sandy sediments, while the subtidal zone was a bare sandy area (Hamid et al., 2016a). Stations 1 and 2, situated near the coastline, are influenced by mangrove ecosystems. Station 6 is in the middle of the bay with a sandy clay substrate in the sea bed (Hamid et al., 2016a).

Sampling

Decapods samplings at each station were done monthly, from April 2013 to March 2014. Sample collections were conducted by gillnets with mesh

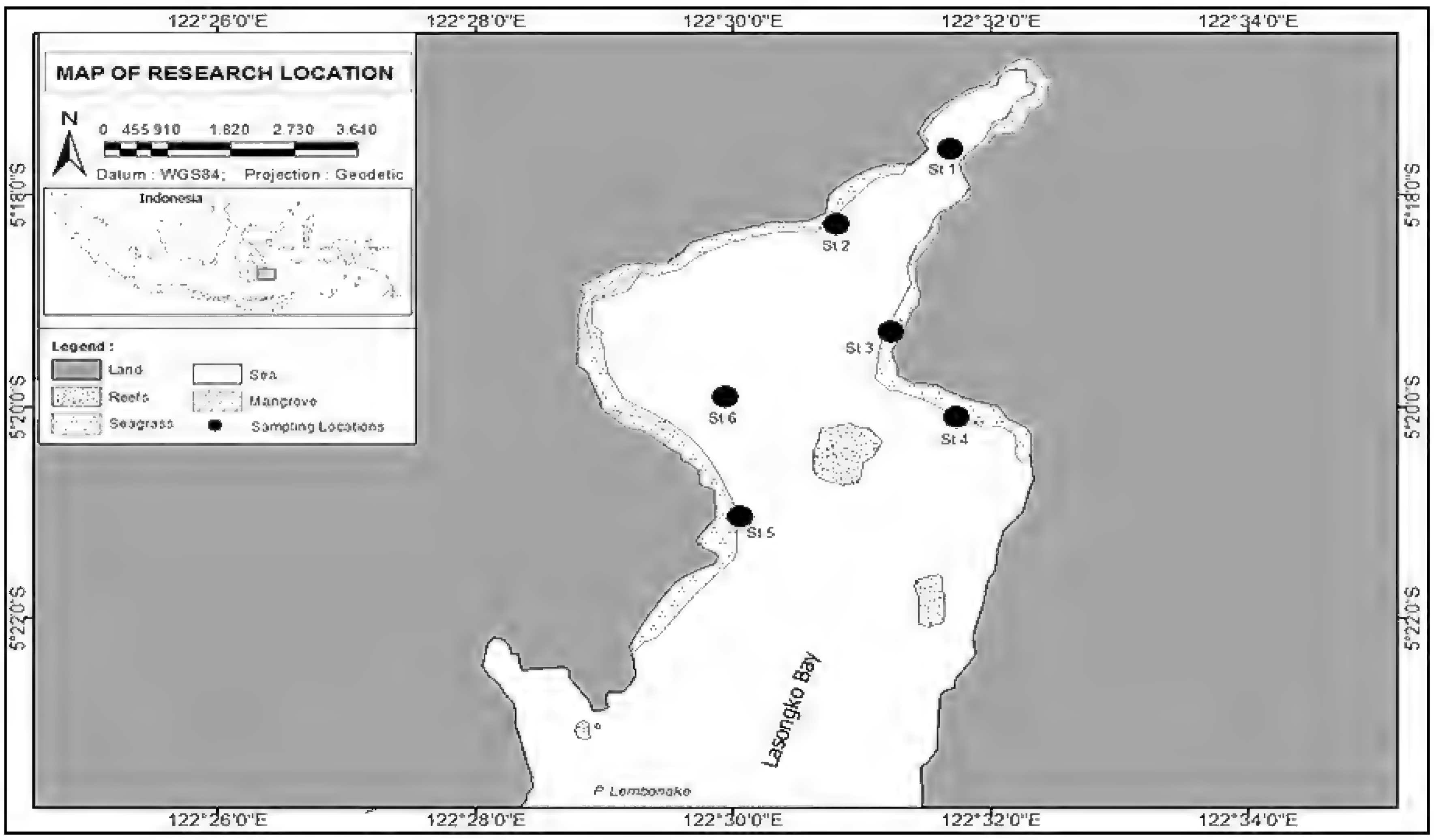

Figure 1. Map showing the location of the study site in Lasongko Bay, Southeast Sulawesi, Indonesia. Sampling sites are indicated by the black dots (adapted from Hamid, 2015).

sizes of 3.81, 6.35, and 8.89 cm. The gillnet was deployed in the afternoon and hauled in the morning of the next day. The decapods caught on each sampling were identified following Ng (1998), Chan (1998), Ng et al. (2008), and Khvorov (2012), and counted. Habitat characteristics such as temperature, salinity, dissolved oxygen, pH, turbidity, and total suspended solids were taken from Hamid (2015).

Data analysis

The data were grouped spatially (station) and temporally (sampling period) for analysis. To evaluate the diversity, three biological indices were used (e.g. Shannon-Wiener index, evenness index, and the Simpson dominance index). The species similarity index between stations was calculated by the Sorensen index (Brower et al., 1990).

RESULTS

Habitat Conditions

Habitat characteristics in Lasongko Bay during the study showed variation, but were still within the optimum limit for decapods life. The range of some environmental parameters are as follow: temperature, 23.6–35.6 °C; turbidity, 0.20–6.78 NTU; total suspended solid, 19.0–293.0 mg. l–1; dissolved oxygen, 3.05–7.77 mg. l–1; salinity, 16.0–35.0 psu; pH, 7.45–8.74 (Hamid, 2015).

Species Composition of Decapods

The collected decapods found during the study were 2508 individuls, consisting of two groups, the Brachyura group (16 families and 34 species) and the Macrura group (3 families and 4 species). All collected decapod crustaceans can be seen in Table 1. Some familes and species have always been found in each station and at each sampling time. These families are Portunidae, Dorippidae, Calappidae, Xanthidae, and Majidae (Figure 2). The species are *Portunus pelagicus*, *Dorippe sinica*, *Callapa hepatica*, *Schizophrys aspera*, *Podothalmus vigil*, *Charybdis anisodon*, *Thalamita crenata*, *T. spinimana*, *T. sima*, and *Lophozozymus pictor*.

Spatial Diversity

Decapods abundance at each station ranged from 243 to 730 individuals and the number of species ranged from 16 to 26 species. The highest abundance and species were found at station 1, while the lowest abundance at station 6 and the lowest number of species at station 3 (Table 1). The Shannon-Weiner diversity index ranged from 0.812 to 0.893. In addition, the evenness and Simpson dominance indices ranged from 0.592 to 0.683 and from 0.215 to 0.313, respectively. The similarity index of the decapod species between stations ranged from 0.560 to 0.831. The highest was found between stations 2 and 3, and the lowest between stations 1 and 4 (Table 2).

Temporal Diversity

According to the sampling period, the number of decapod species found ranged from 10 to 25 species with abundance ranging from 125 to 312 individuals. The highest number of species and abundance were found in March and May, while the lowest in December (Table 3). The Shannon-Wiener diversity ranged from 0.339 to 1.075, and the evenness and Simpson dominance indices ranged from 0.362 to 0.847 and from 0.113 to 0.710, respectively.

Decapoda Species of Economic Value

The number of decapod species with economic value found in this study were 20 species from the families Penaeidae, Portunidae, Calappidae, Dromiidae, Palinuridae, and Scyllaridae. Among the twenty species, six are categorized as decapods with high economic value: *P. pelagicus*, *P. versicolor*, *P. monodon*, *P. merguensis*, *S. serrata*, and *Thenus orientalis*.

DISCUSSION AND CONCLUSIONS

Portunidae was the dominant family found in Lasongko Bay (Table 1 and Figure 2), and this finding is identical to previous researches (Pratiwi & Wijaya, 2013; Varadharajan et al., 2013; Kumaralingan et al., 2013; Sruthi et al., 2014; Anggraeni et al., 2015; Fazrul et al., 2015; Pawar et al., 2017).

No.	Family	Species	Station					
			1	2	3	4	5	6
1.	Calappidae	*Callapa callapa*	1	17	1	9		1
		C. philargius					1	1
		C. hepatica	8	42	8	18	4	6
2.	Dorippidae	*Dorippe sinica*	13	34	29	14	31	33
3.	Dromiidae	*Dromia dormia*		3	4	6	11	2
4.	Epialtidae	*Phalangipus sp.*				1	1	
5.	Grapsidae	*Metopograpsus sp.*	1	3				
6.	Inachidae	*Compascia retusa*				1		
7.	Leucosiidae	*Randalia sp.*	1				2	1
8.	Majidae	*Schizophrys aspera*	19	16	8	3	5	5
9.	Matutidae	*Ashtoret lunaris*	3	2	4	4		3
10.	Menippidae	*Myomenippe hardwickii*	7	15			3	1
11.	Palinuridae	*Panulirus versicolor*	2					
12.	Parthenopidae	*Rhinolambrus pelagicus*	1	7		1	1	5
13.	Penaeidae	*Penaus. monodon*	9					
		P. merguensis	16					
14.	Pilumnidae	*Pilumnus sp.*		10		2		1
		Heteropanope indica				1		3
		Nano pilumnus		3		2		
15.	Portunidae	*Portunus pelagicus*	265	346	132	148	136	115
		P. granulatus				1	2	4
		Podothalmus vigil	40	25	7	9	16	16
		Charybdis affinis	88	7	2	7		6
		C. anisodon	180	39	4	10	10	7
		C. natator	31	6	21	2	4	
		Charybdis sp.	1					
		Thalamita crenata	26	37	3	2	4	2
		T. sima	4	35	17	3	1	5
		T. spinimana	4	33	47	6	12	8
		Thallamita sp.		2	1	1	1	2
		Scylla serrata	2					
16.	Sesarmidae	Neopisesarma sp.	2					
17.	Scyllaridae	*Thenus orientalis*				4	1	
18.	Varunidae	*Hemigrapsus* sp.		7				
19.	Xanthidae	*Lophozozymus pictor*	4	11	9	9	22	9
		Atergatis integerrimus	1					7
		Leptodius sanguineus	1					
		Etisus sp.		2			4	
Number of species			26	23	16	24	21	23
Abundance			730	702	297	264	272	243
Shannon-Wiener index			0.868	0.898	0.822	0.817	0.812	0.893
Evenness index			0.613	0.651	0.683	0.592	0.614	0.656
Simpson Dominance index			0.215	0.260	0.235	0.313	0.254	0.246

Table 1. Decapod family and species found in Lasongko Bay, Southeast Sulawesi, Indonesia.

Station	Similarity index at each station					
	1	2	3	4	5	6
1	-	0.653	0.619	0.56	0.596	0.694
2		-	0.831	0.723	0.727	0.783
3			-	0.800	0.703	0.769
4				-	0.756	0.809
5					-	0.773
6						-

Table 2. Matrix of Sorensen similarity index of Decapods among stations in Lasongko Bay, SE Sulawesi, Indonesia.

Sampling Time	No. of species	Abundance (individual)	Index		
			Shannon -Wiener	Evenness	Simpson Dominance
April 13	11	138	0.339	0.362	0.710
May 13	20	312	0.736	0.568	0.372
June 13	21	233	0.892	0.707	0.238
July13	18	178	0.830	0.693	0.263
Augustus 13	20	160	0.932	0.743	0.210
September	19	129	0.944	0.771	0.178
October 13	19	151	0.994	0.785	0.137
November 13	19	217	1.058	0.847	0.113
December 13	10	125	0.541	0.558	0.435
January 14	24	307	0.946	0.699	0.198
February 14	22	254	1.075	0.806	0.143
March 14	25	218	1.071	0.807	0.129

Table 3. The number of species, abundance, and biological indices of Decapod Crustaceans based on sampling time in Lasongko Bay, Southeast Sulawesi, Indonesia.

Location	No. of species	Diversity index (H')	Sources
Kawhia, New Zealand	29	-	Morley et al., 1997
Minden and Roe Reefs, West Australia	46	-	Richards et al., 2016
Malindi-Ungwana Bay, Kenya	22	< 0.5	Ndoro et al., 2014
Hong Kong waters	22	-	Lui et al., 2007
Mudasal Odai coast, India	34[a]		Sakthivel & Fernando, 2012
North Andaman sea, India	47	2.94-3.38	Kumaralingam et al., 2013
Puducherry coast, India	47	-	Varadharajan et al., 2013
Kanyakumari coast, India	40[a]	-	Sruthi et al., 2014
Tamil Nadu coast, India	55	3.13-5.53	Pillai et al., 2014
Uran coast, India	31[a]	-	Pawar. 2017
Odisha coast, India	29[a]	-	Dev Roy et al., 2017
Shantou Bay, China	41[a]	-	Huang et al., 2011
Pattani coast, Thailand	28	-	Fazrul et al., 2015
Kung Krabaen Bay, Thailand	17	-	Kunsook & Dumrongrojwatthana, 2017
Indonesia :			
South Lombok, seagrass bed	50	-	Moosa & Aswandy, 1994
Anambas Islands	39	0.65 -0.98	Widyastuti, 2007
Lampung Bay, seagrass bed	57	0.66-3.00*	Pratiwi, 2010
Kendari Waters, open waters	15	1.121-3.744*	Pratiwi & Astuti, 2012
Lampung Bay, mangroves	31	0.39-2.10*	Pratiwi & Widyastuti 2013
Matasiri Islands	59	0.97-3.74*	Pratiwi & Wijaya, 2013
West Lombok	85	-	Anggorowati, 2014
Tikus Island, Seribu Islands	31[a]	-	Anggraeni et al., 2015
Lingga, Riau Islands, mangroves	19[a]	0.673-1.954*	Widyastuti, 2016
Lasongko Bay	38	0.377-1.129	This study

Note: * = $\log_2$ a: brachyura only -: no data

Table 4. Number of species and Shannon-Wiener (H') index of Decapods community in some waters of the world.

The number of species and abundance of decapods in this study showed variations both spatially and temporally. It might be due to the spatial-temporal variation in habitat conditions. In terms of abundance, decapods found in this study were more than the ones found in other Indonesia waters (Pratiwi, 2010; Pratiwi & Wijaya, 2013; Anggorowari, 2014; Anggraeni et al., 2015). The number of decapod species found in the waters of Lasongko Bay was still within the range of decapod species found in other waters of the world and Indonesia, ranging from 15 to 85 species (Table 4).

The species number of Brachyura group found in this study were higher than that found by Fahzul et al. (2015), Dev Roy et al. (2017), Kunsook & Dumrongrojwatthana (2017), Pawar et al. (2017), and were lower than that found by Huang et al. (2011), Sruthi et al. (2014), as well as those found by Sakthivel & Fernando (2012). The number of species and abundance of decapods were influenced by the substrate type and seagrass density (Aswandy, 2008; Huang et al., 2011; Anggorowati, 2014; Andrade et al., 2015; Hamid, 2015), as well as temperature, salinity, oxygen, turbidity, and water depth (Lui et al., 2007; Ndoro et al., 2014; Andrade et al., 2015; Hamid, 2015; Kunsook & Dumrongrojwatthana, 2017).

Based on the sampling time, decapods diversity in Lasongko bay was generally low, except in November, February, and March, indicating ecological stress, probably due to fishing intensity. The diversity value of decapods in this study was lower compared to previous studies (Widyastuti, 2007, 2016; Pratiwi, 2010; Pratiwi & Astuti, 2012; Kumaralingam et al., 2013; Pratiwi & Wijaya, 2013; Pratiwi & Widyastuti, 2013a; Pillai et al., 2014; see Table 4). The evenness index of decapods in Lasongko Bay was moderate, indicating that the spatially-temporally distribution of the species tends to spread evenly. It is also supported by the low spatially-temporally dominance index values (Tables 1 and 2). The values of the evenness index and Simpson dominance indicess were still comparable with previous studies (Pratiwi, 2010; Pratiwi & Astuti, 2012; Pratiwi & Wijaya, 2013; Anggorowati, 2014), which ranged from 0.360 to 0.970 and from 0.070 to 0.620, respectively.

The species similarities found in this study tended to vary. Anggorowati (2015) suggests that a species similarity more than 0.61 is high. The species similarity of decapods in this study was higher than the one reported by Kumaralingam et al. (2013), Anggorowati (2014), and Pillai et al. (2014). At stations 2 and 3, 23 species and 16 species were found. These two stations have the highest species similarity of decapods, because all the decapod species found in station 3 are also found in station 2. The two stations are relatively similar to the seagrass bed conditions, i.e. *Thalassia hemprichii* dominated, but the substrate type on the subtidal were different, i.e., on the stations 2, substrate type was sand, while stations 3 has a different substrate type (clay sand) (Hamid 2015; Hamid et al., 2016a).

The species similarity of the decapods between stations 1 and 4 was the lowest. In the two stations, the decapods found belonged to 26 and 24 species, respectively. Of these, only 14 species were found on both stations (Table 2). This may be caused by differences in environmental conditions in both stations. Station 1 is located in the inner part of the bay, influenced by a dense mangrove ecosystem and a low density seagrass bed. The substrate was muddy, its salinity was lower and the water was more turbid compared to other stations (Hamid, 2015; Hamid et al., 2016a). In contrast, station 4 is relatively open, the seagrass bed was large and dense with a sandy substrate (Hamid et al., 2016a). However, there is an interesting thing about station 1. The species of *Panulirus versicolor*, *Penaeus monodon*, *Penaeus merguensis*, *Charybdis* sp., *Scylla serrata*, *Neopisesarma* sp., *Atergatis integerrimus*, and *Leptodius sanguineus* were found only in station 1 and not in any other stations.

The number of the species of economic valuable in this study is the same as found by Lui et al. (2007), and more than the one reported by Kunsook & Dumrongrojwatthana (2017), while the number of species with high economic value were less than Huang et al. (2011), Pratiwi & Astuti (2012), and Pratiwi & Wijaya (2013). *Portunus pelagicus* is one of the most valuable species, and has been a target for fishing in Lasongko Bay since the 1970s until now (Hamid et al., 2016d). The other 37 decapod species are bycatch of the blue swimming crab fishery in Lasongko Bay using gillnets. The gillnet was considered to be a selective fishing gear compared to trap for blue swimming crab fisheries (Fazrul et al., 2015; Kunsook & Dumrongrojwatthana, 2017), this finding however showed that there were still some other decapod species caught as bycatch. The

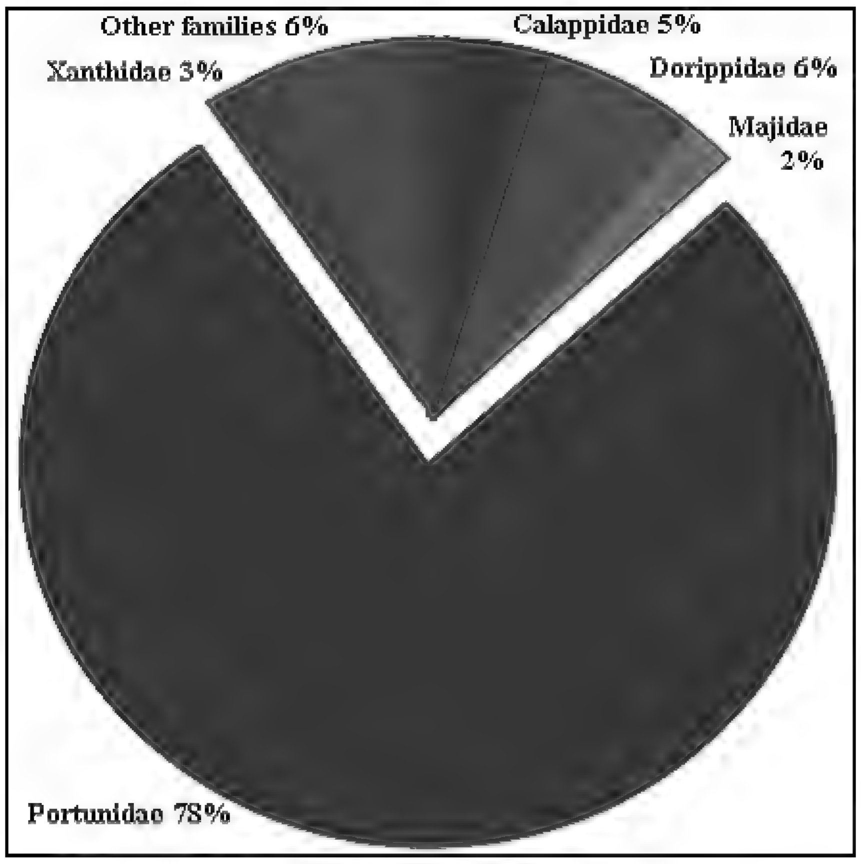

Figure 2. Family composition of the dominant Decapods based on abundance in Lasongko Bay, SE Sulawesi, Indonesia.

list of bycatches would be longer if fishes and molluscs were to be included.

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